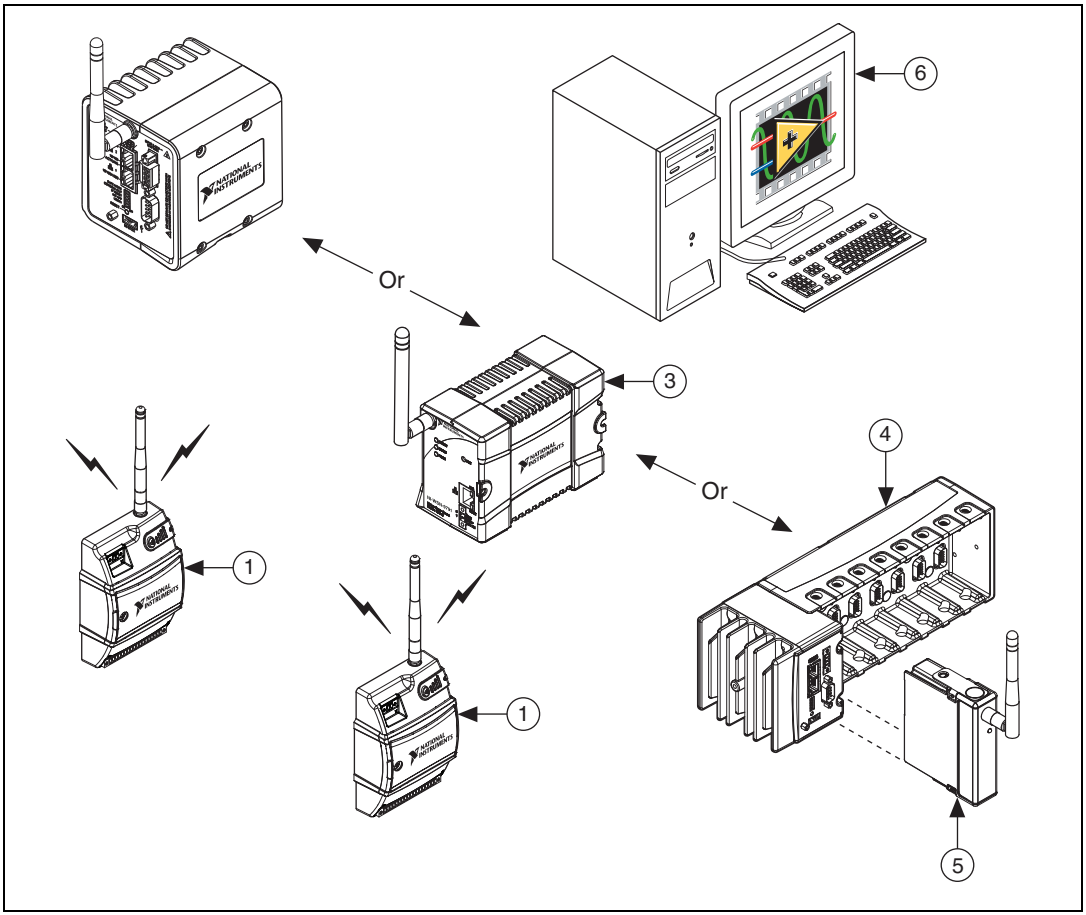
USER GUIDE AND SPECIFICATIONS

NI WSN-3214

NI Wireless Sensor Network 4-Channel, Quarter/Half/Full Bridge Input Node

This user guide describes how to use the NI WSN-3214 input node and lists its specifications. The NI WSN-3214 is a four-channel, low-power, wireless quarter-bridge, half-bridge, and full-bridge device that works with other NI WSN-32*xx* nodes and gateways to form a wireless sensor network. Figure 1 shows the NI WSN system components.



1	NI WSN-32*xx* Nodes	4	NI CompactRIO Chassis
2	NI 9792 WSN Real-Time Gateway	5	NI 9795 WSN C Series Gateway
3	NI WSN-9791 Ethernet Gateway	6	PC Running NI Software

Figure 1. NI WSN System Components

NATIONAL INSTRUMENTS

The NI WSN system receives and analyzes distributed sensor data through one or more NI WSN gateways, up to 36 NI WSN nodes per gateway, and multiple PCs.

When you connect the NI WSN gateway, you can use a separate host PC running Windows, or a NI CompactRIO chassis running NI LabVIEW Real-Time, to display measurement results, status information, and to change the NI WSN gateway and NI WSN-3214 device settings.

Dimensions

Figure 2 shows the NI WSN-3214 device dimensions.

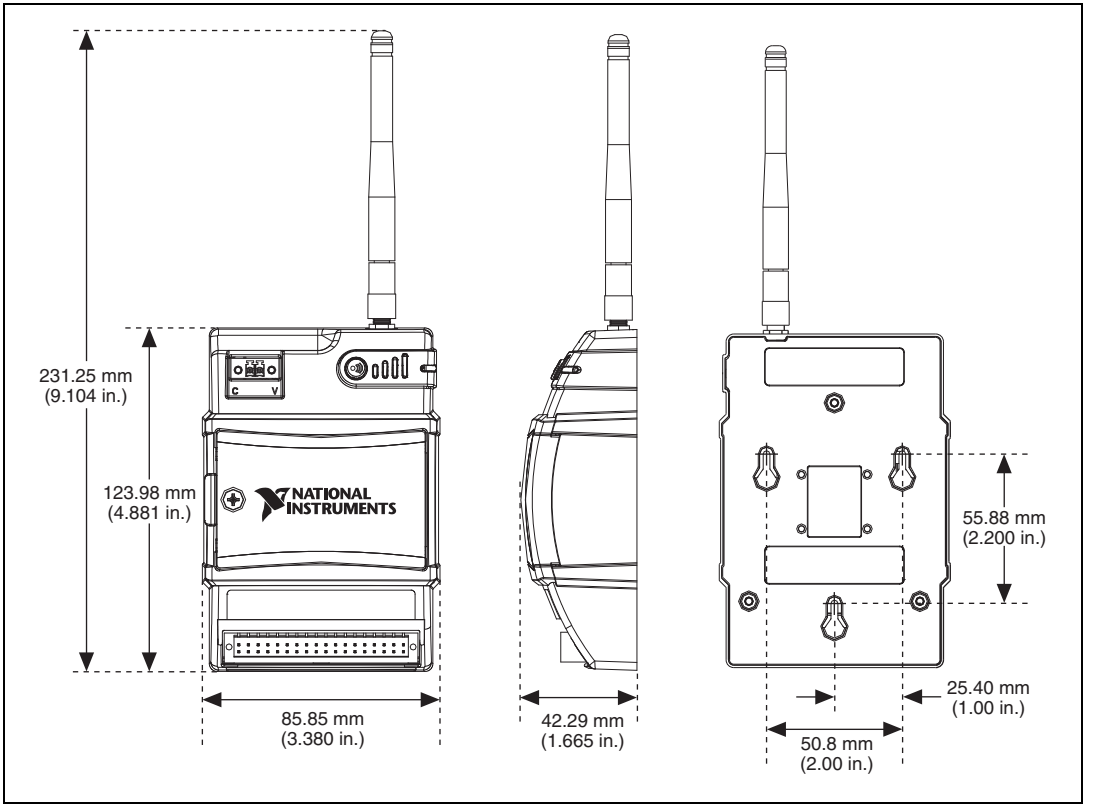


Figure 2. NI WSN-3214 Device Dimensions

Safety Guidelines

Operate the NI WSN-3214 device only as described in this user guide.

Hot Surface This icon denotes that the component may be hot. Touching this component may result in bodily injury.

NI WSN Safety Information

The following section contains important safety information that you *must* follow when installing and using NI WSN products.

Caution Do not operate the NI WSN product in a manner not specified in the user manual or operating instructions. Product misuse can result in a hazard. You can compromise the safety

protection built into the product if the product is damaged in any way. If the product is damaged, return it to National Instruments for repair.

Caution Do not substitute parts or modify the NI WSN product. Use the product only with the devices, accessories, and cables specified in the installation instructions.

Caution Do not operate NI WSN products in an explosive atmosphere or where there may be flammable gases or fumes.

Caution If you need to clean a NI WSN product, wipe it with a dry towel. The product *must* be completely dry and free from contaminants before you return it to service.

Caution Operate the product indoors only at or below Pollution Degree 2. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity.

Caution You *must* insulate signal connections for the maximum voltage for which the NI WSN product is rated. Do not exceed the maximum ratings for the product. Do not install wiring while the product is live with electrical signals. Do not remove or add connector blocks when power is connected to the NI WSN system. Avoid contact between your body and the connector block signal wiring when hot-swapping devices.

Caution To comply with safety regulations, use only recommended batteries with this product. Refer to the *Battery Power* section for the recommended battery types.

Safety Guidelines for Hazardous Locations

The NI WSN-3214 is suitable for use in Class I, Division 2, Groups A, B, C, D, T4 hazardous locations; Class I, Zone 2, AEx nC IIC T4 and Ex nL IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the NI WSN-3214 in a potentially explosive environment. Not following these guidelines may result in serious injury or death.

Caution Observe the battery manufacturers' operating temperature ratings listed in the *Battery operating temperature range* specification section.

Caution Do not disconnect the power supply wires and connectors from the device unless power has been switched off.

Caution Do not install or remove the device unless power has been switched off.

Caution Substitution of components may impair suitability for Class I, Division 2.

Caution For Zone 2 applications, install the WSN system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Special Conditions for Hazardous Locations Use in Europe

The NI WSN-3214 has been evaluated as Ex nA nL IIC T4 equipment under DEMKO Certificate No. 07 ATEX 0626664X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations, in ambient temperatures of –40 °C ≤ Ta ≤ 70 °C.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) as stated in the product specifications. These requirements and limits are designed to provide reasonable protection against harmful interference when the product is operated in its intended operational electromagnetic environment.

This product is intended for use in industrial locations. There is no guarantee that harmful interference will not occur in a particular installation, when the product is connected to a test object, or if the product is used in residential areas. To minimize the potential for the product to cause interference to radio and television reception or to experience unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

The following statements contain important EMC information needed before installing and using this product:

Caution To ensure the specified EMC performance, product installation requires either special considerations or user-installed, add-on devices. See the product installation instructions for further information.

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories.

Caution To ensure the specified EMC performance, operate this product with a DGND terminal on the I/O connector tied to earth ground or use the NI recommended external power supply (NI part number 780703-01) or equivalent.

Caution The inputs/outputs of this product can be damaged if subjected to Electrostatic Discharge (ESD). To prevent damage, industry-standard ESD prevention measures must be employed during installation, maintenance, and operation.

This product may become more sensitive to electromagnetic disturbances in the operational environment when test leads are attached or when connected to a test object.

Related Documentation

Check `ni.com/manuals` for the most recent documentation. For a complete list of documentation related to the NI WSN system, refer to `ni.com/info` and enter `rdwsnrd`.

In addition to this guide, the following documents may be useful when configuring your NI WSN system:

- The getting started guide for your NI WSN gateway(s)
- The user guide and specifications for your NI WSN node(s)
- *Configuring WSN in MAX*, available from **Start»All Programs»National Instruments» NI-WSN** *LabVIEW Help for WSN Devices*, available in LabVIEW from **Help»LV Help»WSN Devices Help**
- *NI-WSN Readme*, available on the software installation disc included with your gateway

Training Courses

If you need more help getting started developing an application with NI products, NI offers training courses. To enroll in a course or obtain a detailed course outline, refer to `ni.com/training`.

Technical Support on the Web

For additional support, refer to `ni.com/support` or `zone.ni.com`.

Software Overview

Note Refer to the *NI-WSN Readme*, available on the software installation disc included with your gateway or at `ni.com/drivers`, for NI software application version support.

The NI-WSN software is supported by Windows 7/Vista/XP and contains the following components:

- NI Measurement & Automation Explorer (MAX)
- NI-WSN

NI-WSN software and NI MAX manage the hardware configurations and simplify programmatic access to I/O channels. The NI-WSN software is downloadable from `ni.com/drivers` and on the software installation disc included with your NI WSN gateway. You can download a current version of NI-WSN software from `ni.com/support`. Using your Web browser, go to `ni.com/support` and select **Drivers and Updates»Distributed I/O»Wireless Sensor Networks**, and then select the latest version of NI-WSN software. If you are using other software, refer to the accompanying installation instructions.

What You Need to Get Started

To set up and use NI LabVIEW with the NI WSN-3214 device, you need the following:

- NI WSN gateway
- NI WSN-3214 device(s) with a 5–30 V power supply or four alkaline or lithium AA 1.5 V batteries for each node. Refer to the *Battery Power* section for recommended battery types.
- Mounting hardware (DIN rail or panel-panel mount)
- Ethernet cable/connection
- 1/8 in. flathead and number 2 Phillips screwdrivers
- NI-WSN 1.3.1 or later
- Host PC running Windows 7/Vista/XP
- NI LabVIEW 2011 (32-bit) or later
- NI LabVIEW 2011 WSN Module or later (optional)
- **(NI 9792 WSN Real-Time Gateway Only)**—NI LabVIEW (32-bit) Real-Time Module or later
- **(NI 9795 WSN C Series Gateway Only)**—NI-RIO 4.0 or later and NI LabVIEW (32-bit) Real-Time Module
- Related hardware and software documentation

For more information about NI-WSN software versions, go to `ni.com/info` and enter `wsnsoftware`.

Unpack the Device and Install the Antenna

Remove the device from the package and inspect the device. Contact NI if the device appears damaged. Do not install a damaged device.

Caution The device is static sensitive. Always properly ground yourself and the equipment when handling or connecting to the device.

Caution An electrostatic discharge (ESD) to the antenna connector when the product is operating may cause interference or disruption of the wireless signal. To prevent ESD, do not attempt to remove the antenna while the product is operating or ensure that you employ industry-standard ESD prevention measures.

Caution The antenna must be attached to the NI WSN device in order for the NI WSN device to function correctly.

To attach the antenna, align the antenna with the mount and screw it on, as shown in Figure 3.

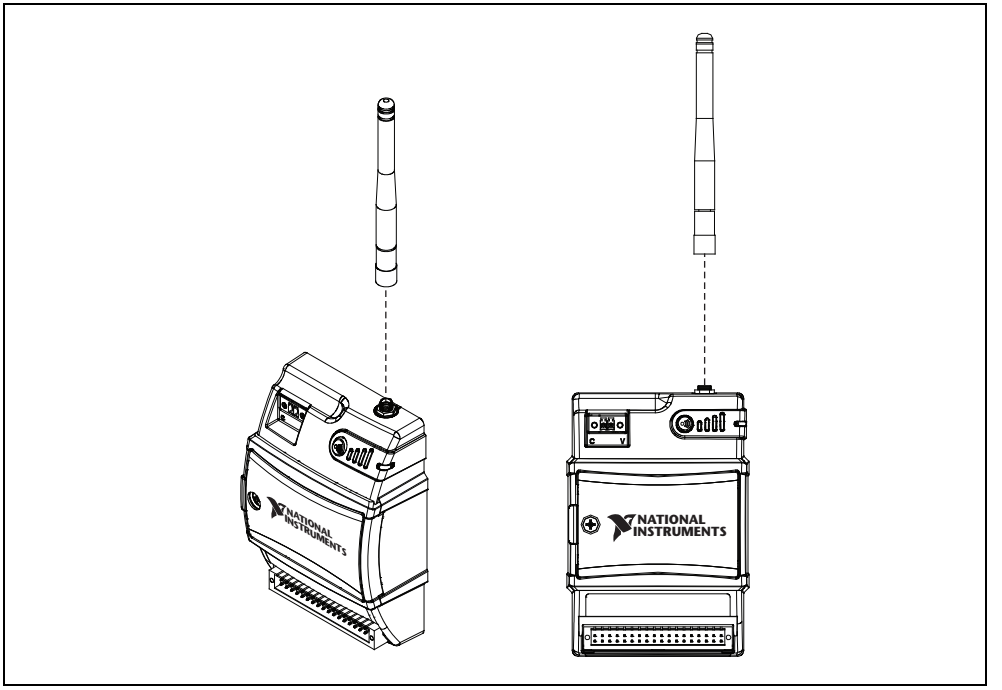


Figure 3. Attach the Antenna to the Device

Mounting the NI WSN-3214 Device

You can mount the NI WSN-3214 on a panel or on a 35 mm DIN rail. For kit accessory ordering information, refer to the NI WSN product page accessory section at `ni.com`. Before using any of these mounting methods, remove and save the serial number sticker located on the back of the NI WSN-3214 device for future use when configuring your device in the software. For the NI WSN-3214 device dimensions, refer to Figure 2.

Caution Your installation *must* allow 50.8 mm (2 in.) of clearance in front of the device for common connector cabling, such as the 36-terminal detachable screw terminal connector.

Attaching the NI WSN-3282 DIN Rail (Optional)

You can mount the NI WSN-3214 on a standard 35 mm DIN rail using a NI WSN-3282 DIN rail clip, NI part number 781074-01. Complete the following steps to mount the NI WSN-3214 on a DIN rail:

Caution Power off the device before mounting it to the DIN rail.

Note Use thread-forming screws to permanently affix the DIN rail clip to the device. Unscrewing and reinstalling the thread-forming screws produces a compromised connection between the DIN rail clip and the device.

1. Fasten the DIN rail clip to the NI WSN-3214 using a number 2 Phillips screwdriver and the four 8-32 × 5/16 in. thread-forming screws that shipped with the DIN rail clip(s). Figure 4 shows how to fasten the DIN rail clip to the NI WSN-3214.

Caution Do not use screws longer than 5/16 in. to fasten the DIN rail clip to the NI WSN-3214.

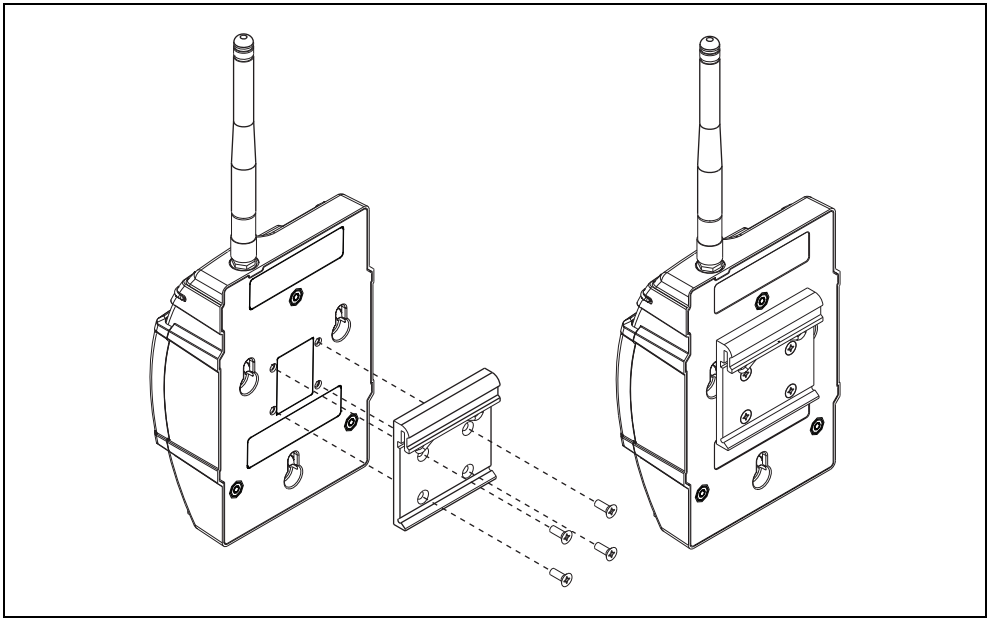
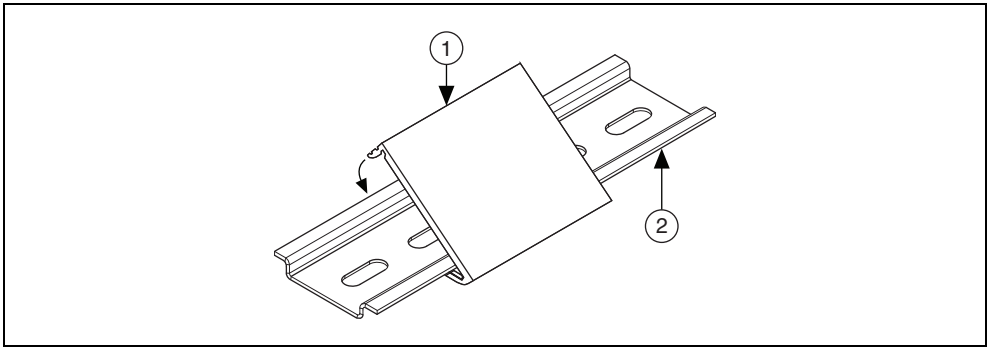


Figure 4. NI WSN-3214 Device DIN Rail Installation

2. Insert one edge of the DIN rail into the deeper opening of the DIN rail clip, as shown in Figure 5.



1	DIN Rail Clip (Without Device)	2	DIN Rail

Figure 5. DIN Rail Clip Installation

3. Press down firmly on the NI WSN-3214 to compress the spring until the clip locks into place on the DIN rail.

Using a Panel Mount Accessory

The NI WSN-3280/3281 panel mount accessories, NI part numbers 780999-01 and 781073-01, each include a retention clip and knob and integrated strain relief for power and I/O wires. You can use the NI WSN-3280 panel mount accessory to attach the NI WSN-3214 device to a panel or other flat surface. The NI WSN-3281 panel mount accessory also includes a magnetic mount for attaching the NI WSN-3214 device to metallic surfaces. Figure 6 shows the NI WSN-3214 panel mounting dimensions.

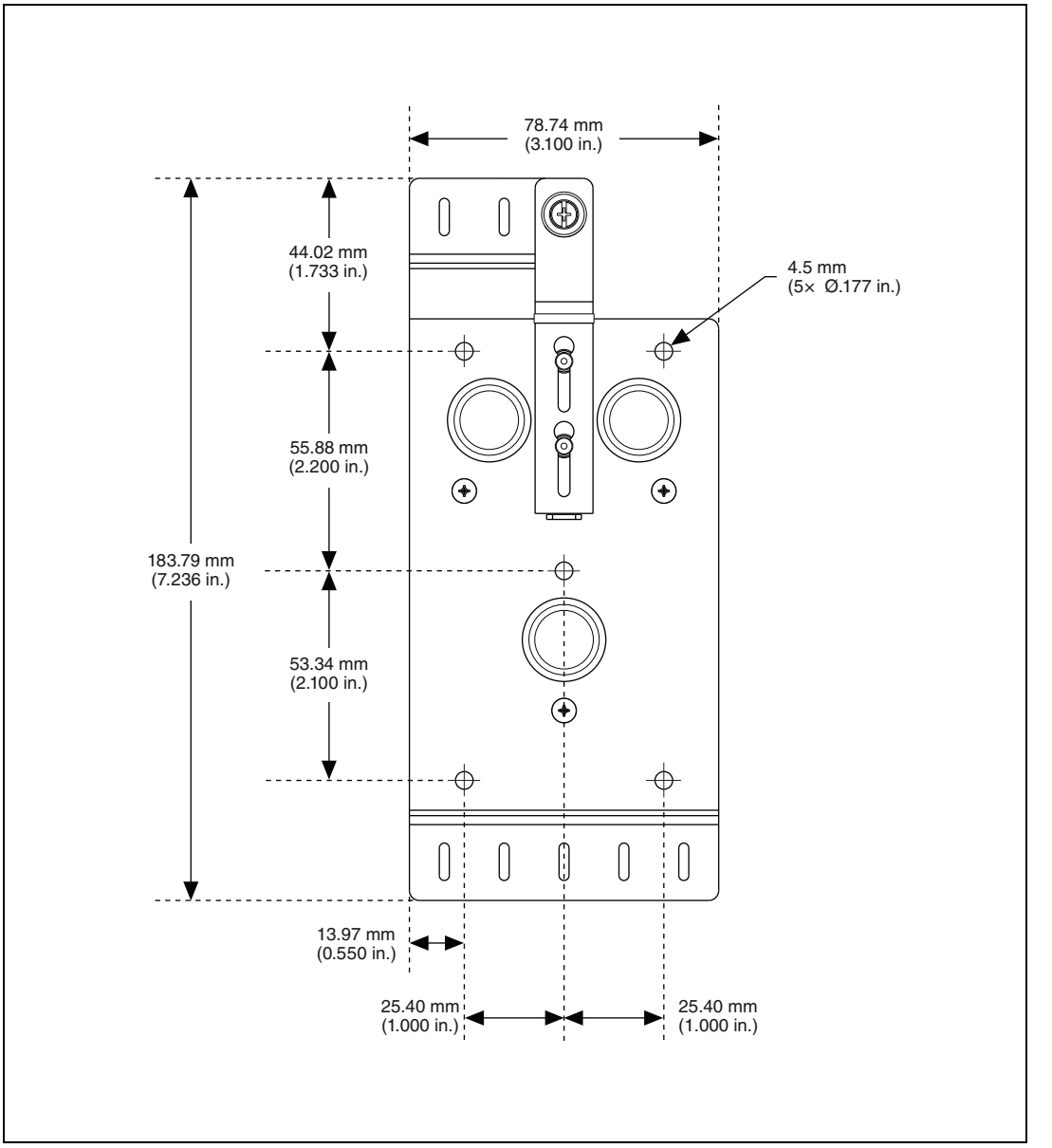
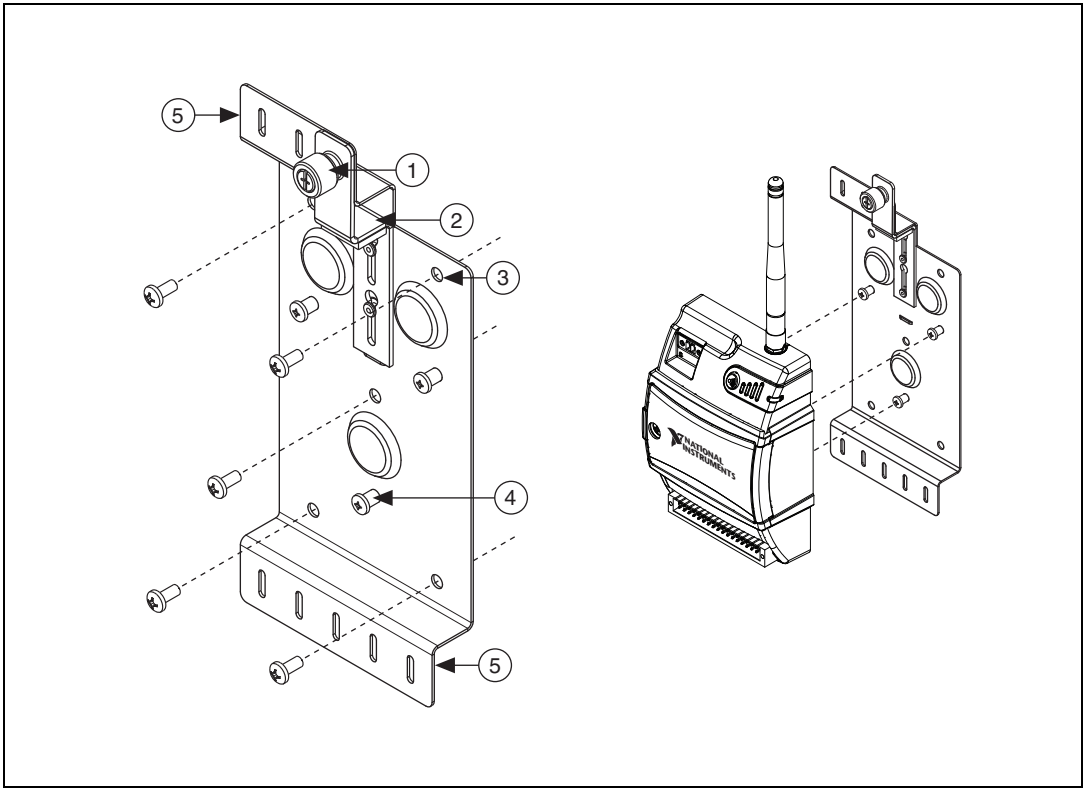


Figure 6. NI WSN-3214 Device Panel Mount Dimensions



1	Retention Knob	4	Integrated Mounting Pin
2	Retention Clip	5	Power and I/O Strain Relief
3	Mounting Hole		

Figure 7. Panel Mount Accessory

Refer to Figure 7 while completing the following steps to mount the NI WSN-3214 on a panel:

1. **(NI WSN-3280)** Bolt or screw the panel mount accessory to a panel using five 8-32 or M4 screws.
   (NI WSN-3281) Attach the panel mount accessory using the integrated magnet.
2. Slide the NI WSN-3214 device into the panel mount accessory, as shown in Figure 7.
3. Slide the retention clip down and tighten the panel mount knob to secure the NI WSN-3214 device, as shown in Figure 8.
4. (Optional) Secure any I/O signal or power supply cabling to the panel mount accessory using a zip-tie and the integrated strain relief slots.

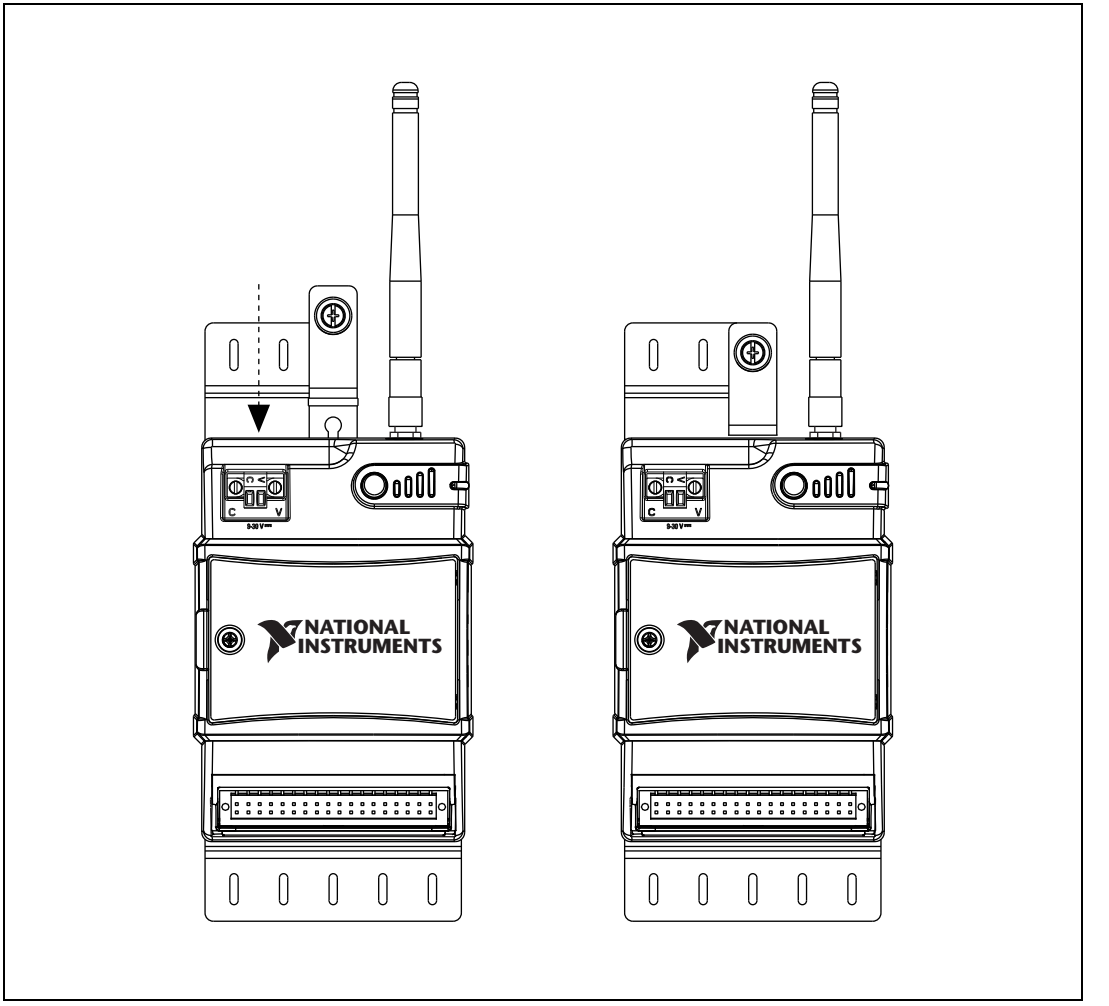


Figure 8. Slide Retention Clip Down and Tighten Panel Mount Knob

Using the Integrated Panel Mount Slots

You can also mount the NI WSN-3214 to a panel using the integrated panel mount slots, as shown in Figure 9.

1. Attach three number 8 or M4 pan head screws in the mounting panel, leaving 0.1 in. space under the head of each screw. Refer to Figure 2 for the correct hole pattern and dimensions.
2. Slide the NI WSN-3214 device onto the panel.

Note In this configuration, the NI WSN-3214 is held in place only by the weight of the device and the friction of the screw attachment. Use the DIN rail clip or panel mount accessories in high vibration environments.

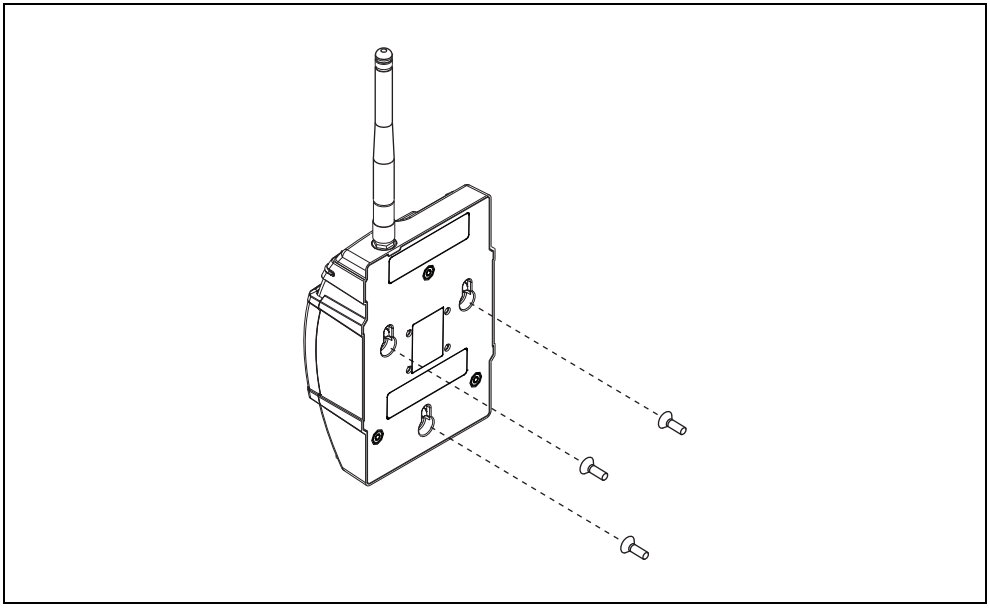


Figure 9. Integrated Panel Mount Slots

Caution Disconnect power before removing the device from the panel.

Setting Up the NI WSN-3214 Device

The following sections discuss setting up the NI WSN-3214 for use.

Installing the Software

For more information about NI-WSN software, go to `ni.com/info` and enter `wsnsoftware`.

You must be an administrator to install NI software and devices on your computer. Before connecting the hardware, install the following software in the following order:

1. NI LabVIEW 2011 or later
2. NI LabVIEW Real-Time Module 2011 or later (required only for NI 9795 and NI 9792 support)
3. NI-RIO 4.0 or later (required for NI 9795 support)
4. NI LabVIEW WSN Module 2011 or later
5. NI-WSN 1.3.1 or later (includes NI MAX)

Tip NI-WSN 1.3.1 or later and NI MAX are available for download at `ni.com/support`.

Note After installation of NI-WSN, the *NI Wireless Sensor Network Getting Started Guide* is available from **Start»All Programs»National Instruments»NI-WSN**.

Powering the NI WSN-3214 Device

The NI WSN-3214 device can be powered by either an external power supply or four AA alkaline or lithium batteries. Refer to the *Specifications* section for details about the input power and battery requirements.

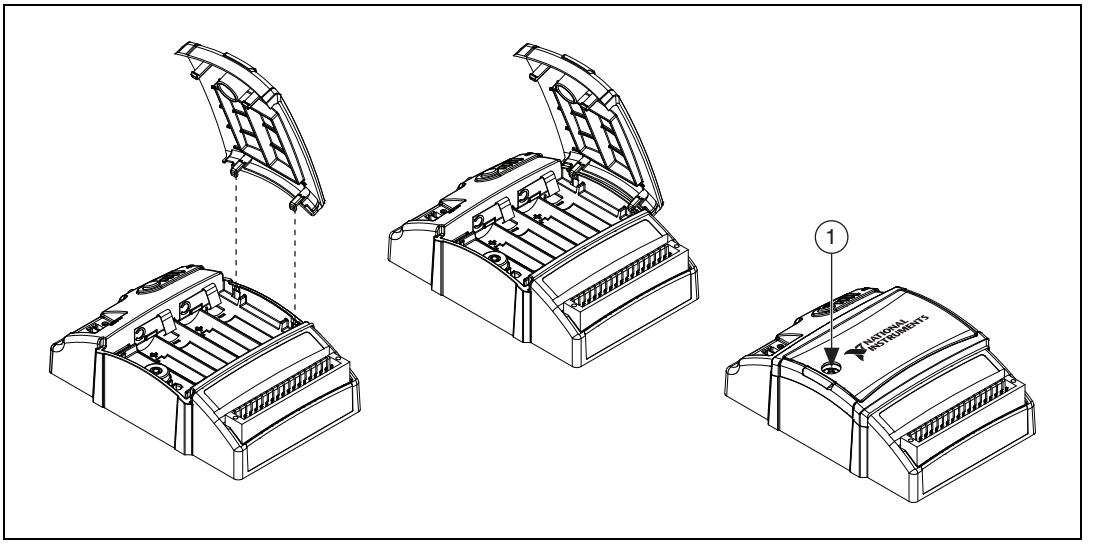
If both battery and external power are connected, the NI WSN-3214 functions from the external power input. The device is designed to provide battery backup in the event of loss of external power and automatically switches to battery power when external power is lost.

Installing Batteries

To install batteries in the NI WSN-3214 device, complete the following steps:

Caution The device is static sensitive. Always properly ground yourself and the equipment when handling or connecting to the device.

1. Loosen the battery compartment retention screw and remove the compartment cover, as shown in Figure 10.



1	Battery Retention Screw

Figure 10. NI WSN-3214 Battery Compartment

Caution Using the incorrect battery type creates an explosion risk. Do not use rechargeable batteries. Refer to the *Battery Replacement and Disposal* section for information about how to dispose of used batteries.

Note When using the NI WSN-3214 device on battery power, you should configure the device as an end node so that it sleeps most of the time. Running a device configured in router mode from battery power greatly reduces the battery life. The device ships from the factory configured as an end node. For more information about how to switch the node from an end node to router mode, refer to *Configuring WSN in MAX*, available from **Start»All Programs»National Instruments»NI-WSN**.

2. Install four AA alkaline or lithium batteries in the device, making sure to install them with the correct polarity. Figure 12 shows the battery polarity markings inside the device battery compartment.
3. Reinstall the battery compartment cover and tighten the retention screw.

Connecting External Power to the NI WSN-3214 Device

Caution To ensure the specified EMC performance, do not connect the power input to a DC mains supply or to any supply requiring a connecting cable longer than 30 m (100 ft.). A DC mains supply is a local DC electricity supply network in the infrastructure of a certain site or building.

To connect an external power supply to the NI WSN-3214, complete the following steps:

1. Remove the 2-position mini-combicon plug from the device. Loosen the retaining screws if necessary.

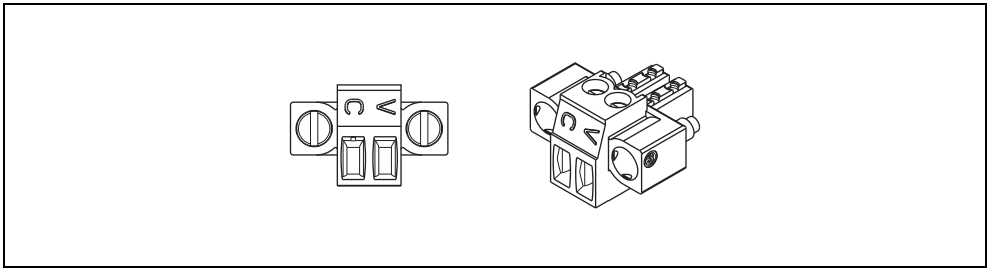


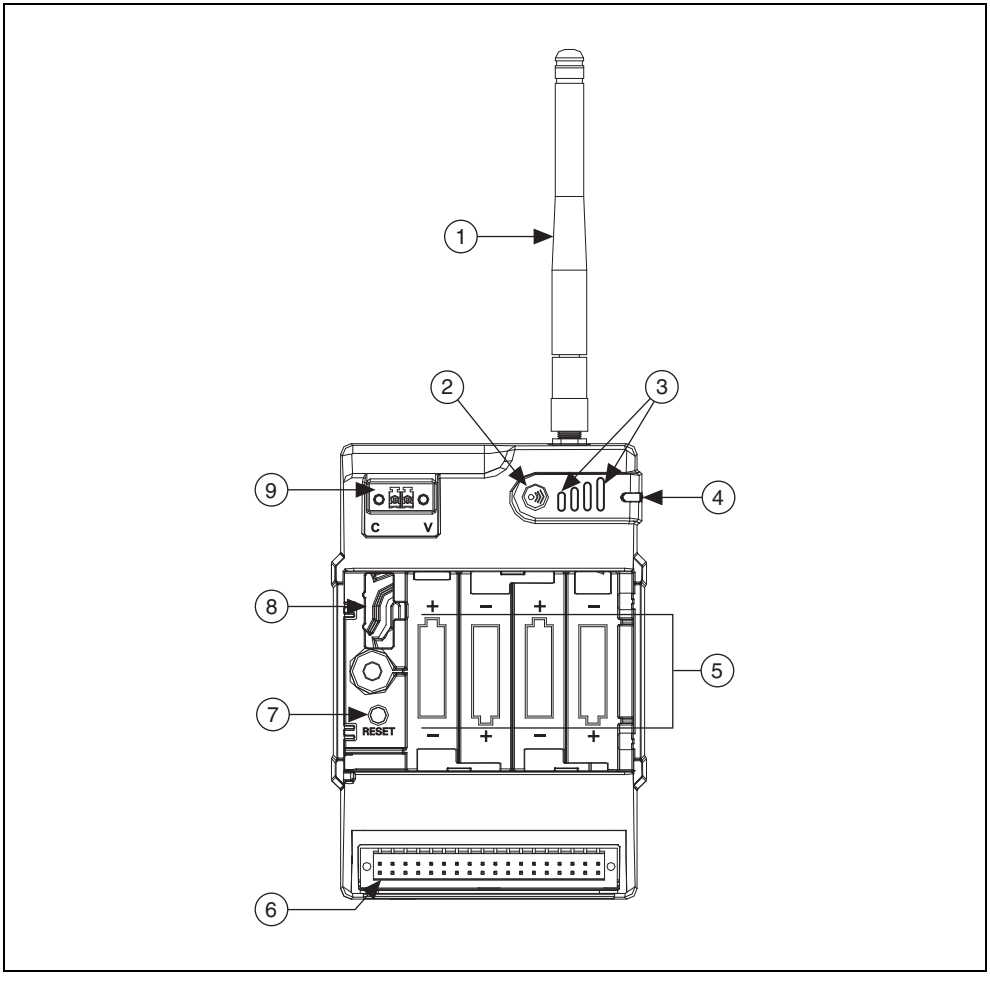
Figure 11. 2-Position Mini-Combicon Plug

2. Connect the external power supply positive lead to the V terminal.
3. Connect the negative (common) lead to the C terminal.
4. Reinstall the 2-position mini-combicon plug in the device and tighten the retaining screws.

Caution You must use a UL Listed ITE power supply marked LPS with the NI WSN-3214. The power supply must also meet any safety and compliance requirements for the country of use.

Device Interface

Figure 12 shows the NI WSN-3214 device interface.



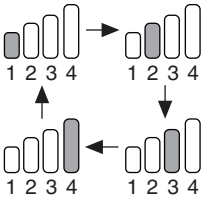
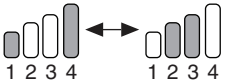
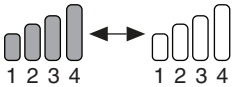
1	Antenna	6	I/O Connector
2	WSN Connect Button	7	Reset Button
3	Signal Strength/Status LEDs	8	Pro2 Port (Reserved for Future Use)
4	User LED	9	5–30 V External Power Input
5	Battery Slots/Polarity Indicators		

Figure 12. NI WSN-3214 Node Interface

Signal Strength/Status LED Indicators

The NI WSN-3214 has four signal strength/status LED indicators, which flash twice before displaying signal strength information. Table 1 shows the status and signal strength LED patterns.

Table 1. Signal Strength and Status LED State/Node Status

LED Indication Mode	LED State	LED Pattern	Device Status
Signal Strength—LEDS 1–4 blink twice and then display the signal strength for three seconds	LED 1–4 OFF		Low Signal
	LED 1 ON, LED 2–4 OFF		Poor
	LED 1–2 ON, LED 3–4 OFF		Fair
	LED 1–3 ON, LED 4 OFF		Good
	LED 1–4 ON		Excellent
Status Indication	Each LED 1–4 blinking in succession		Searching for a network
	LED 1, 4 and 2, 3 alternate blinking		Updating firmware
	LED 1–4 continuously blinking		Error. Reboot device. If problem persists, reset device to factory default settings. Go to `ni.com/support` for additional troubleshooting steps.

WSN Connect Button

Note Refer to your NI WSN gateway documentation for detailed instructions about how to connect a NI WSN-3214 to the NI WSN gateway.

The NI WSN-3214 is equipped with a WSN connect button, as shown in Figure 12. The button controls network connection and the LEDs, which display connection status.

Pressing the WSN connect button results in the device responses shown in Table 2.

Table 2. WSN Connect State/Device Status

Current Device State	Duration of Button Press	Result
Initial power on, not connected	Any duration	Node turns on and searches for an available network.
Connected to a NI WSN gateway	<5 seconds	Node blinks all four signal strength LEDs twice, and then displays the signal strength, as shown in Table 1.
	≥5 seconds	Node leaves current network and searches for a new network.

Reset Button

The NI WSN-3214 is equipped with a reset button, as shown in Figure 12.

Pressing the reset button results in the following device responses:

- When pressed for fewer than 5 seconds, the device reboots with the current configuration.
- When pressed for 5 seconds or more, the device reboots into Factory Default Mode, which returns the device user configuration to the factory-set defaults.

Using the NI WSN-3214 Device

Caution To ensure the specified EMC performance, operate this product only with shielded cables and accessories. Cable shields must be connected to one of the DGND pins of the I/O connector.

Note When you insert or remove a new sensor from the NI WSN-3214, slight changes in the excitation voltages can cause a mismatch between the internal half-bridge completion resistors and the half-bridge sensors, which results in a change in the measurement offsets. National Instruments recommends performing bridge calibrations of quarter-bridge or half-bridge sensors after connecting all sensors to the NI WSN-3214, and after removing, or attaching any additional sensor.

Strain-Gage Sensor Configurations

This section describes the configurations and signal connection of various supported strain-gage configuration types.

Quarter-Bridge Type I

This section provides information for the quarter-bridge strain-gage configuration type I. The quarter-bridge type I measures either axial or bending strain. Figure 13 shows how to position a strain-gage resistor in an axial and bending configuration. Figure 14 shows the quarter-bridge type I circuit wiring diagram.

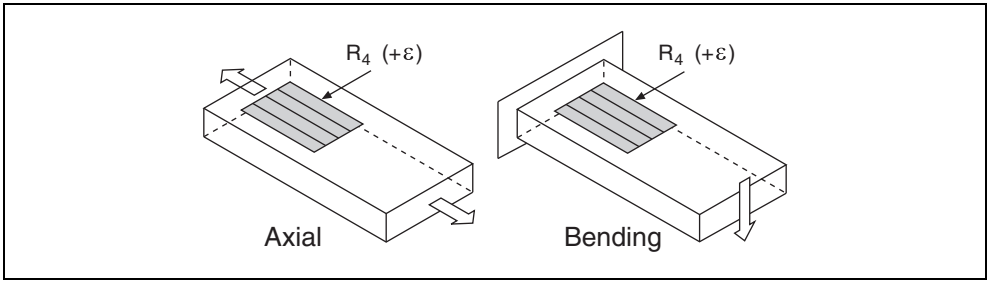


Figure 13. Quarter-Bridge Type I Measuring Axial and Bending Strain

A quarter-bridge type I configuration has the following characteristics:

- A single active strain-gage element is mounted in the principal direction of axial or bending strain.
- A passive quarter-bridge completion resistor (R_3) is required in addition to half-bridge completion resistors (R_1 and R_2). All of these resistors are provided by the NI WSN-3214 module.
- Sensitivity ~ 0.5 µV/V per µε, for GF = 2.0.

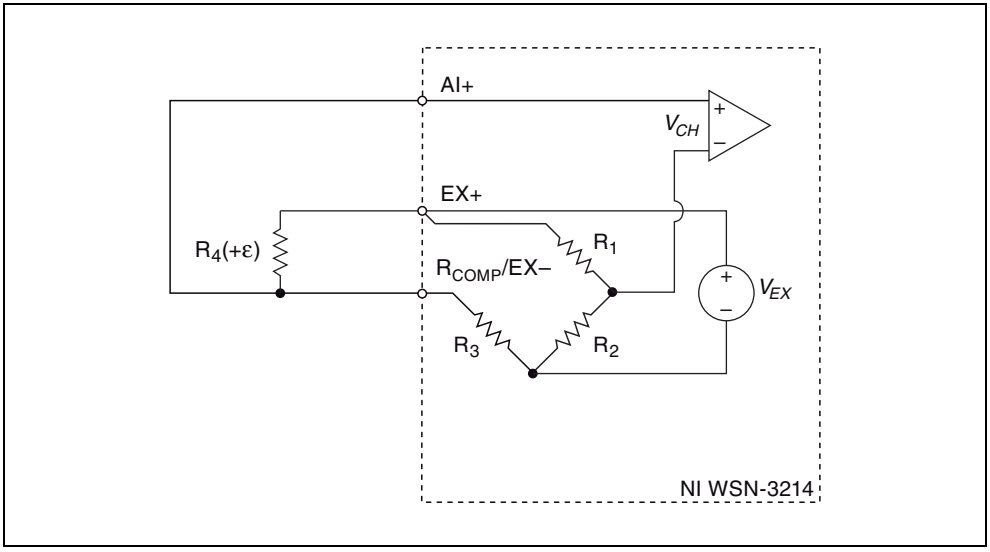


Figure 14. Quarter-Bridge I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2—Half-bridge completion resistors located inside the NI WSN-3214.
- R_3—Quarter-bridge completion resistor located inside the NI WSN-3214. You can select to use a bridge completion of 350 Ω or 1 kΩ.
- R_3 must be equal to the nominal resistance of the active gage (R_4).
- R_4—Active element measuring tensile strain (+ε). You provide this element.
- *GF*—Gage Factor, specified by the gage manufacturer.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.

- V_r—Offset compensated ratiometric bridge output defined by the following equation.
- V_{CH}—Measured voltage of the bridge:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain(\varepsilon) = \frac{-4V_r}{GF(1+2V_r)}$$

To compensate for lead resistance errors shunt calibration should be used. For more information, refer to the *Shunt Calibration* section.

Half-Bridge Type I

This section provides information for the half-bridge strain-gage configuration type I. The half-bridge type I measures either axial or bending strain. Figure 15 shows how to position strain-gage resistors in an axial and bending configurations. Figure 16 shows the half-bridge type I circuit wiring diagram.

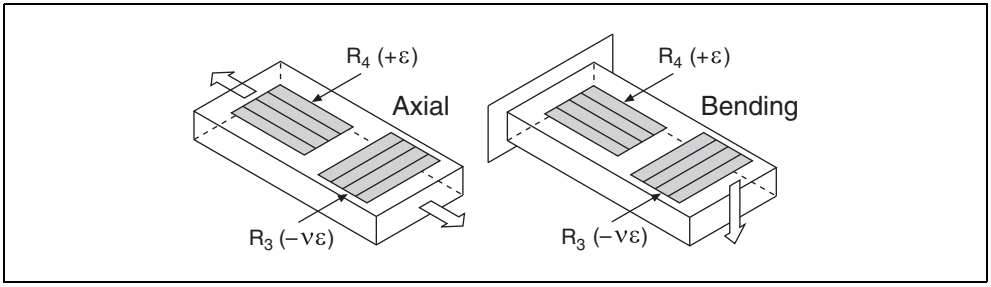


Figure 15. Half-Bridge Type I Measuring Axial and Bending Strain

A half-bridge type I has the following characteristics:

- Two active strain-gage elements. One strain-gage element is mounted in the direction of axial strain while the other acts as a Poisson gage and is mounted perpendicular to the principal axis of strain.
- Half-bridge completion resistors (R_1 and R_2) are provided by the NI WSN-3214.
- Sensitive to both axial and bending strain.
- Sensitivity ~ 0.5 µV/V per µε, for GF = 2.0, ν = 0.

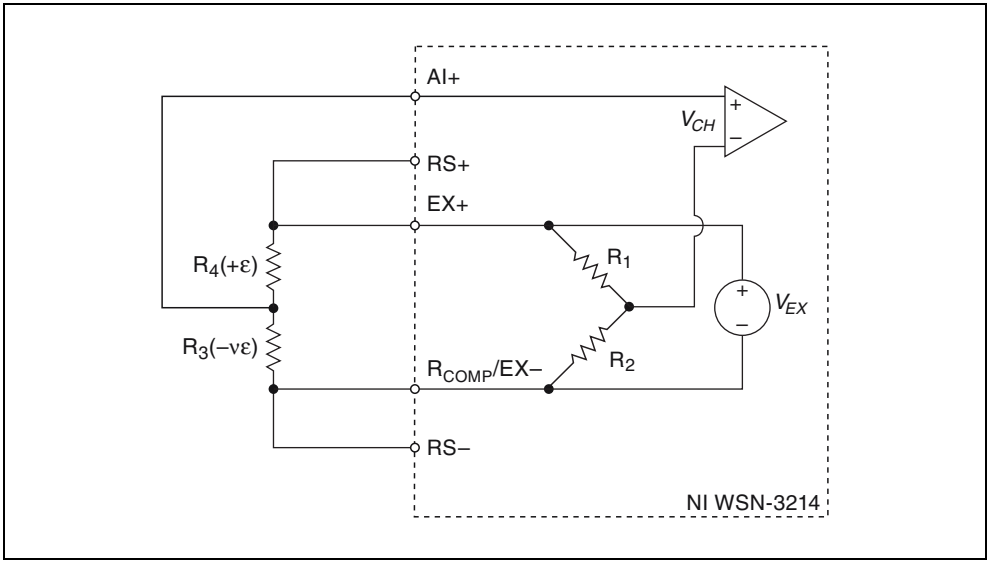


Figure 16. Half-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2—Half-bridge completion resistors located inside the NI WSN-3214.
- R_3—Active element measuring compression from Poisson effect ($-\nu\varepsilon$).
- R_4—Active element measuring tensile strain ($+\varepsilon$).
- *GF*—Gage Factor, specified by the gage manufacturer.
- ν—Poisson's ratio, defined as the negative ratio of transverse strain to axial strain (longitudinal) strain. Poisson's ratio is a material property of the specimen you are measuring.
- V_{CH}—Measured voltage of the bridge.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.
- V_r—Offset compensated ratiometric bridge output defined by the following equation:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain(\varepsilon) = \frac{-4V_r}{GF[(1+\nu) - 2V_r(\nu - 1)]}$$

Half-Bridge Type II

This section provides information for the half-bridge strain-gage configuration type II. The half-bridge type II only measures bending strain. Figure 17 shows how to position strain-gage resistors in a bending configuration. Figure 18 shows the half-bridge type II circuit wiring diagram.

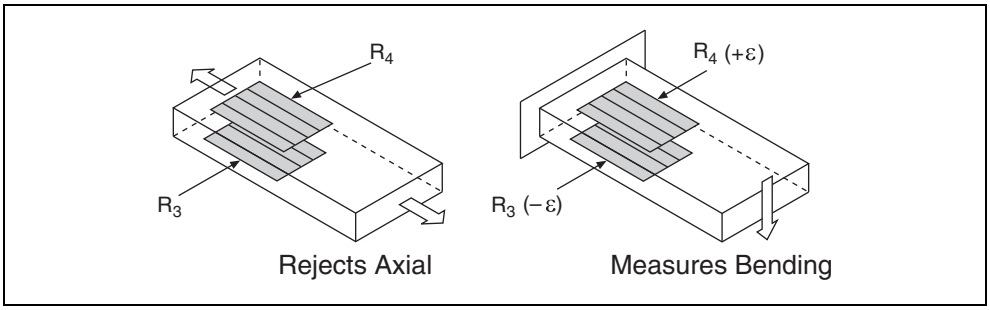


Figure 17. Half-Bridge Type II Rejecting Axial and Measuring Bending Strain

A half-bridge type II configuration has the following characteristics:

- Two active strain-gage elements. One strain-gage element is mounted in the direction of bending strain on one side of the strain specimen (top) while the other is mounted in the direction of bending strain on the opposite side (bottom).
- Half-bridge completion resistors (R_1 and R_2) are provided by the NI WSN-3214.
- Sensitive to bending strain.
- Rejects axial strain.
- Sensitivity ~ 1.0 μV/V per με, for GF = 2.0.

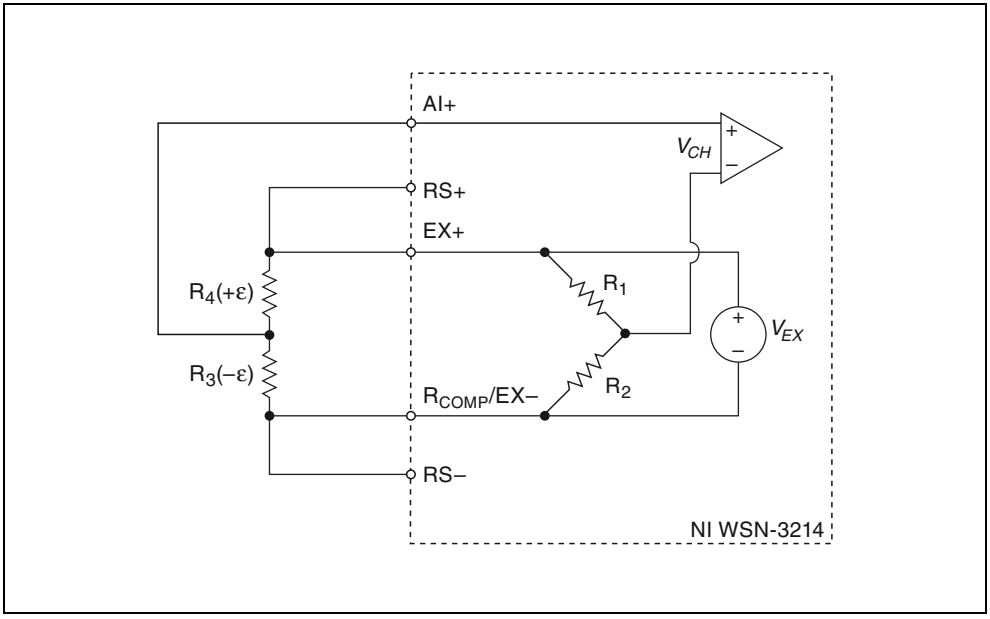


Figure 18. Half-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2—Half-bridge completion resistors located inside the NI WSN-3214.
- R_3—Active element measuring compressive strain (–ε).
- R_4—Active element measuring tensile strain (+ε).
- *GF*—Gage Factor, specified by the gage manufacturer.
- V_{CH}—Measured voltage of the bridge.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.
- V_r—Offset compensated ratiometric bridge output defined by the following equation:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain\ (\varepsilon) = \frac{-2V_r}{GF}$$

Full-Bridge Type I

This section provides information for the full-bridge strain-gage configuration type I. The full-bridge type I only measures bending strain. Figure 19 shows how to position strain-gage resistors in a bending configuration. Figure 20 shows the full-bridge type I circuit wiring diagram.

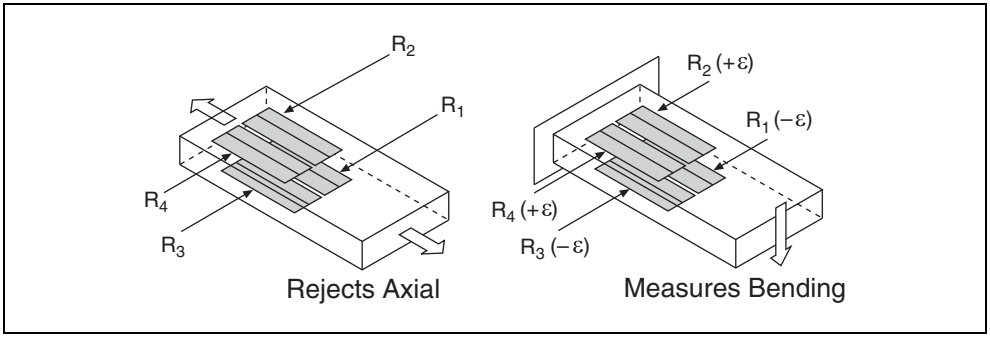


Figure 19. Full-Bridge Type I Rejecting Axial and Measuring Bending Strain

A full-bridge type I configuration has the following characteristics:

- Four active strain-gage elements. Two strain-gage elements are mounted in the direction of bending strain on one side of the strain specimen (top) while the other two are mounted in the direction of bending strain on the opposite side (bottom).
- Highly sensitive to bending strain.
- Rejects axial strain.
- Sensitivity ~ 2 μV/V per με, for GF = 2.0.

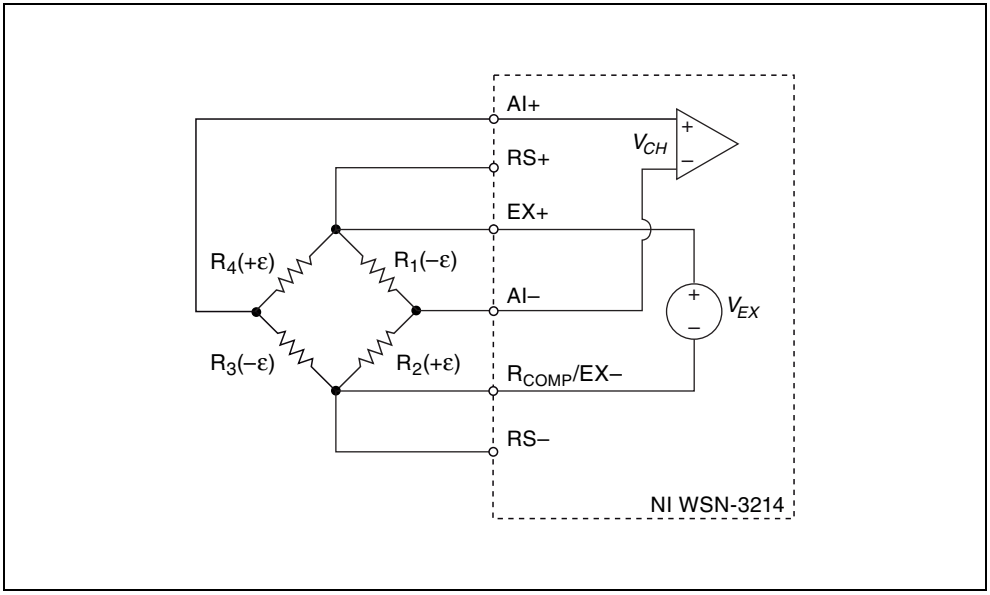


Figure 20. Full-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1—Active element measuring compressive strain (–ε).
- R_2—Active element measuring tensile strain (+ε).
- R_3—Active element measuring compressive strain (–ε).
- R_4—Active element measuring tensile strain (+ε).
- *GF*—Gage Factor, specified by the gage manufacturer.
- V_{CH}—Measured voltage of the bridge.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.
- V_r—Offset compensated ratiometric bridge output defined by the following equation:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain\ (\varepsilon) = \frac{-V_r}{GF}$$

Full-Bridge Type II

This section provides information for the full-bridge type II strain-gage configuration. The full-bridge type II only measures bending strain. Figure 21 shows how to position strain-gage resistors in a bending configuration. Figure 22 shows the full-bridge type II circuit wiring diagram.

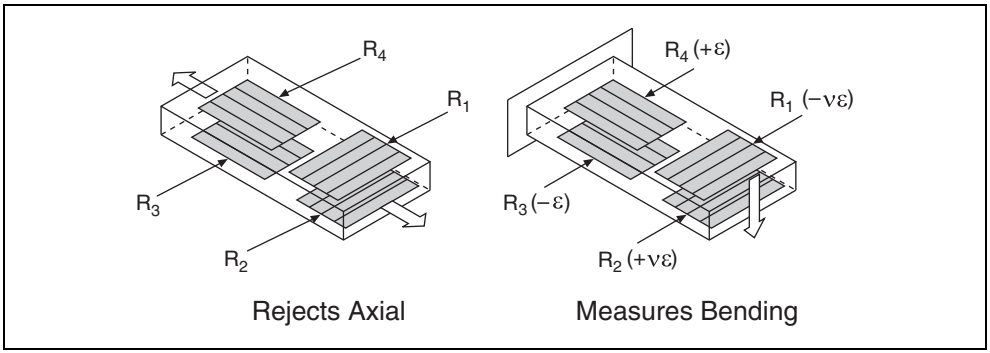


Figure 21. Full-Bridge Type II Rejecting Axial and Measuring Bending Strain

A full-bridge type II configuration has the following characteristics:

- Four active strain-gage elements. Two are mounted in the direction of bending strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom). The other two act together as a Poisson gage and are mounted transverse (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom).
- Rejects axial strain.
- Sensitivity ~ 1.0 μV/V per με, for GF = 2.0, ν = 0.

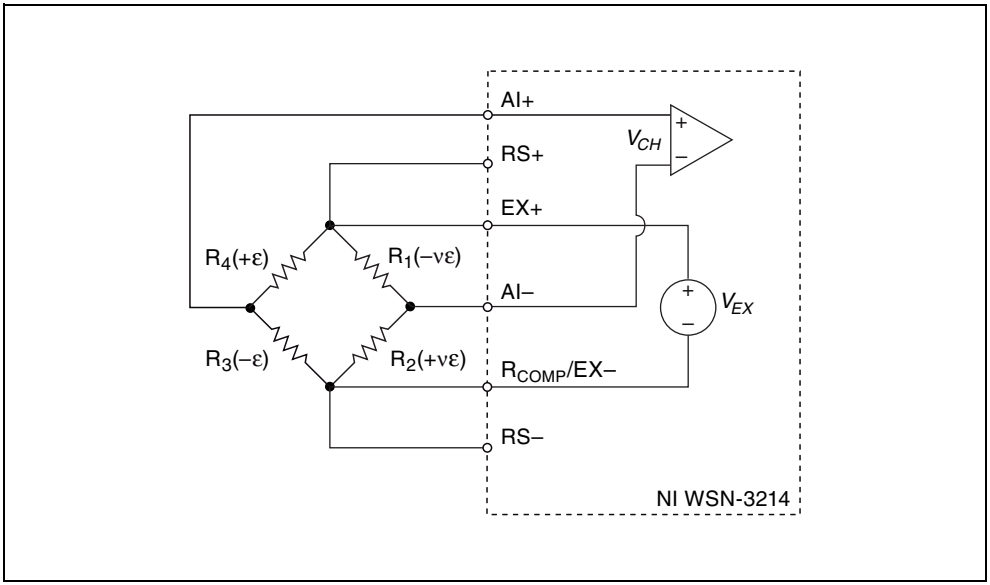


Figure 22. Full-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1—Active element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2—Active element measuring tensile Poisson effect ($+\nu\varepsilon$).
- R_3—Active element measuring compressive strain ($-\varepsilon$).
- R_4—Active element measuring tensile strain ($+\varepsilon$).
- *GF*—Gage Factor, specified by the gage manufacturer.
- ν—Poisson's ratio, defined as the negative ratio of transverse strain to axial strain (longitudinal) strain. Poisson's ratio is a material property of the specimen you are measuring.
- V_{CH}—Measured voltage of the bridge.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.
- V_r—Offset compensated ratiometric bridge output defined by the following equation:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain(\varepsilon) = \frac{-2V_r}{GF(1+\nu)}$$

Full-Bridge Type III

This section provides information for the full-bridge strain-gage configuration type III. The full-bridge type III only measures axial strain. Figure 23 shows how to position strain-gage resistors in an axial configuration. Figure 24 shows the full-bridge type III circuit wiring diagram.

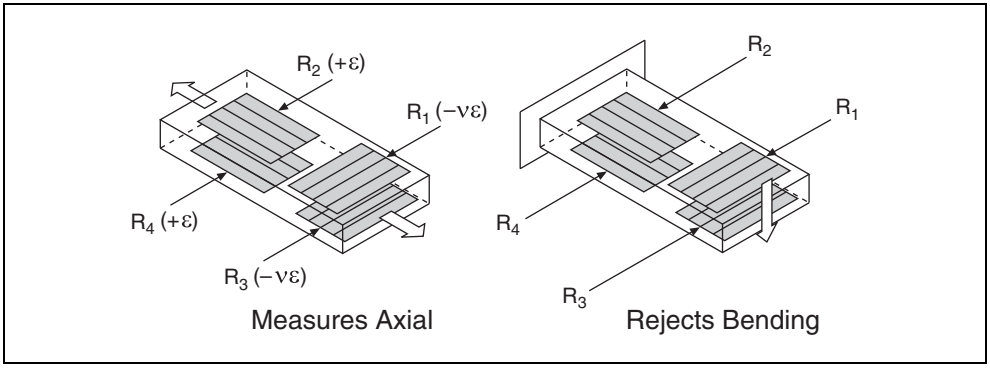


Figure 23. Full-Bridge Type III Measuring Axial and Rejecting Bending Strain

A full-bridge type III configuration has the following characteristics:

- Four active strain-gage elements. Two strain-gage elements are mounted in the direction of axial strain with one on one side of the strain specimen (top) while the other is on the opposite side (bottom). The other two act together as a Poisson gage and are mounted transverse (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom).
- Rejects bending strain.
- Sensitivity ~ 1.0 μV/V per με, for GF = 2.0, ν = 0.

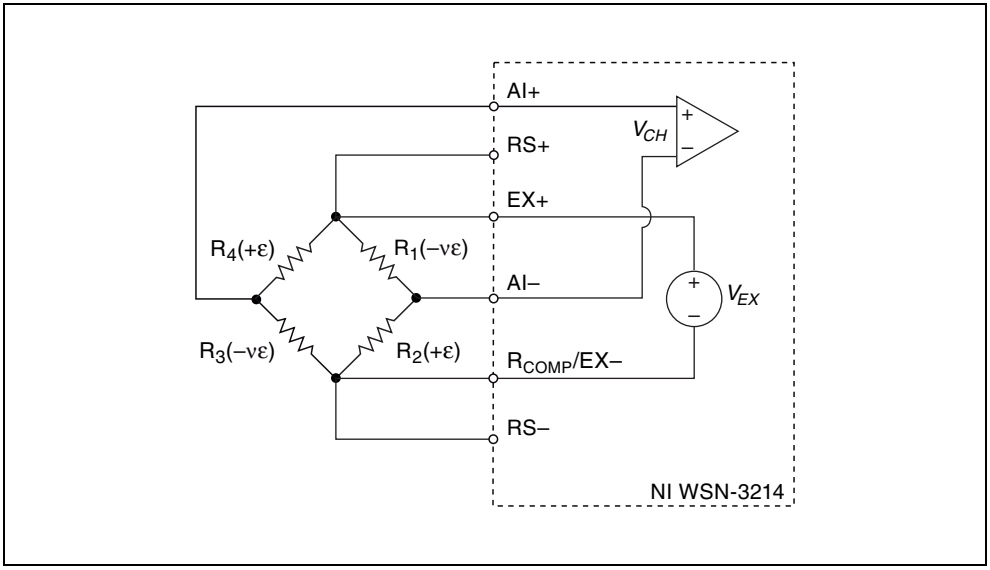


Figure 24. Full-Bridge Type III Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1—Active element measuring compressive Poisson effect (–νε).
- R_2—Active element measuring tensile strain (+ε).
- R_3—Active element measuring compressive Poisson effect (–νε).
- R_4—Active element measuring the tensile strain (+ε).
- *GF*—Gage Factor, specified by the gage manufacturer.
- ν—Poisson's ratio, defined as the negative ratio of transverse strain to axial strain (longitudinal) strain. Poisson's ratio is a material property of the specimen you are measuring.
- V_{CH}—Measured voltage of the bridge.
- V_{EX}—Excitation voltage provided by the NI WSN-3214.
- V_r—Offset compensated ratiometric bridge output defined by the following equation:

$$V_r = \left(\frac{V_{CH}}{V_{EX}}\right) \times \text{Shunt Calibration} - \text{Offset Null}$$

Note The ratio of the bridge output voltage to the excitation voltage is calculated internally on the NI WSN-3214. Shunt Calibration is only supported for quarter-bridge. If you are switching from using a quarter-bridge to a half-bridge or a full-bridge configuration, you need to specify 1 for Shunt Calibration, and then perform Offset Null in the software.

The NI WSN-3214 converts the readings to strain using the following equation:

$$strain(\varepsilon) = \frac{-2V_r}{GF[(\nu + 1) - V_r(\nu - 1)]}$$

Analog Input Circuitry

Excitation Voltage

The NI WSN-3214 uses a fixed 2 V excitation to supply the bridges. This is generated internally from the external power supply or batteries. Bridge excitation current is limited to 6.4 mA per channel. The excitation current for a single bridge is

$$\frac{2V}{R}$$

where R is the total resistance of the bridge.

For a quarter-bridge or half-bridge, R is equal to two times the resistance of each element. For a full-bridge, R is equal to the resistance of each element. If you are using a 350 Ω full-bridge, the excitation current is 5.7 mA. If you are using a 1 kΩ half-bridge and quarter-bridge, the excitation current is 1.1 mA. You cannot use 120 Ω bridges, because they require more than 6.4 mA. Refer to the *Battery Considerations* section for more information about how the battery life changes with the type of bridge used.

Connection Options to Correct for Resistance Errors

Wiring resistance can create gain errors in bridge circuits. The NI WSN-3214 provides two mechanisms to correct for these errors: remote sensing and shunt calibration. The gage and completion resistance tolerances create offset errors. The NI WSN-3214 provides offset nulling to correct for this error.

Remote Sensing

Remote sensing continuously and automatically corrects for errors in excitation leads, and is only supported for half-bridge and full-bridge sensors.

Note The NI-WSN 3214 does not support remote sense with quarter-bridge sensors.

Long wire and small gauge wires have greater resistance, which can result in gain error. The resistance in the wires that connect the excitation voltage to the bridge causes a voltage drop, which is a source of gain error. The NI WSN-3214 includes remote sensing to compensate for this gain error. Connect remote sense wires to the points where the excitation voltage wires connect to the bridge circuit. Figure 25 shows how to connect remote sense wires to the NI WSN-3214.

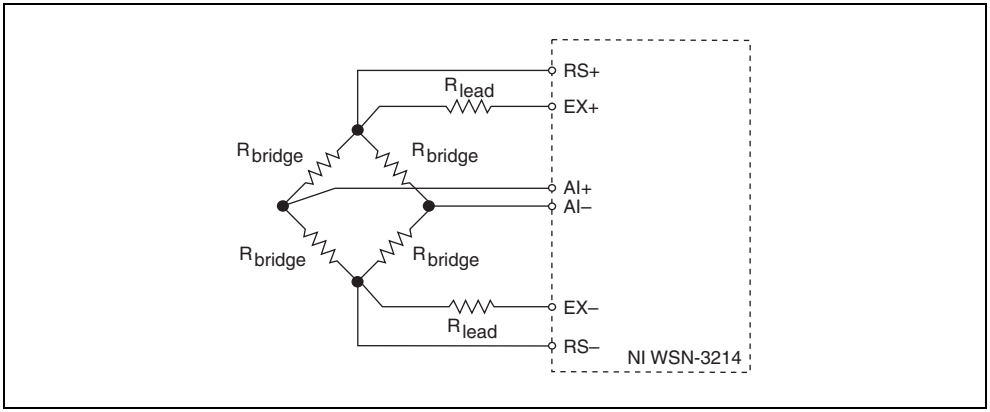


Figure 25. Connecting Remote Sense Wires to the NI WSN-3214

The actual bridge excitation voltage is smaller than the voltage at the EX+ and EX– leads. If you do not use remote sensing of the actual bridge voltage, the resulting gain error is:

$$\frac{R_{lead}}{R_{bridge}} \text{ for half-bridge sensors and}$$

$$\frac{2 \cdot R_{lead}}{R_{bridge}} \text{ for full-bridge sensors.}$$

If you connect the remote sense signals directly to the bridge resistors, the NI WSN-3214 senses the actual bridge voltage and adjusts the excitation voltage to compensate for the gain errors caused by the resistance of the EX+ and EX– leads. There is a limit to the amount of resistance that can be compensated for, which is:

$$\frac{100 \text{ mV}}{\text{Excitation current}}$$

For example, if you are using a 350 Ω full-bridge, the amount of resistance that can be compensated for is

$$\frac{100 \text{ mV}}{(5.7 \text{mA})} = 17\Omega$$

Shunt Calibration

Remote sensing corrects for resistances from the EX pins on the NI WSN-3214 to the sensor, and shunt calibration corrects for these errors and for errors caused by wire resistance within an arm of the bridge. Shunt calibration is most useful with quarter-bridge sensors because there may be significant resistance in the wiring to the active resistor in the bridge. Refer to Figure 26 for a diagram of this setup. The NI WSN-3214 shunt calibration circuitry consists of a precision resistor and a software-controlled switch. Refer to the software help for information about enabling the shunt calibration switch for the NI WSN-3214.

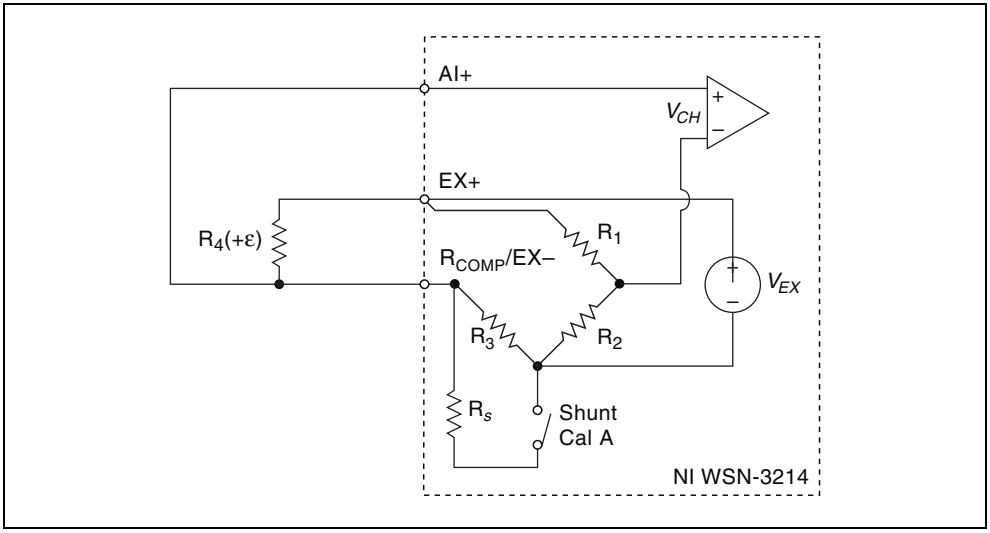


Figure 26. Shunt Calibration Circuitry

Shunt calibration involves simulating the input of strain by changing the resistance of an arm in the bridge by some known amount. This is accomplished by shunting, or connecting, a large resistor of known value across one arm of the bridge, creating a known strain-induced change in resistance. You can then measure the output of the bridge and compare it to the expected voltage value. You can use the results to correct gain errors in the entire measurement path or to verify general operation to gain confidence in the setup.

Note The NI WSN-3214 does not support shunt calibration for the half-bridge and full-bridge measurement types. The NI-WSN 3214 supports shunt calibration for quarter-bridge only.

Offset Nulling

For each new installed bridge-sensor, the bridge does not output exactly 0 mV/V when not under load. Slight variations in resistance among the bridges legs generate some nonzero initial offset voltage. To apply software compensation for the bridge, perform an offset nulling calibration.

The NI WSN-3214 measures the bridge while not under load, and then uses this measurement as the initial bridge voltage when scaling readings from the bridge. This method is simple, fast, and requires no manual adjustments. The disadvantage of the software compensation method (in contrast to hardware compensation) is that software compensation does not physically remove the offset of the bridge. If the offset is large enough, it limits the amplifier gain you can apply to the output voltage, thus limiting the dynamic range of the measurement.

Noise Considerations

Using the NI WSN-3214 in noisy environments creates additional noise in the measurements. One common scenario is to observe the 50 Hz or 60 Hz noise in the spectrum of your measurement. This can be caused by a nearby device that is supplied from the mains. The WSN-3214 is capable of filtering the 50 Hz and 60 Hz in this situation by selecting the filter acquisition modes in NI-WSN or in NI LabVIEW WSN.

National Instruments recommends using shielded cabling to lessen the susceptibility to noise. For full/half-bridge measurements, use a shielded, twisted pair cable. Pair EX +/– and RS +/– together. When using full-bridge, pair IN +/–.

When powering the NI WSN-3214 from a floating power supply source like an external battery or isolated power supply, the measurements are susceptible to picking up noise. National Instruments recommends connecting the shield of the cable to both the mounting plate of the strain-gage or the metal casing of a bridge-based sensor and the DGND pin on the NI WSN-3214. Or, connect the DGND pin on the NI WSN-3214 to Earth GND.

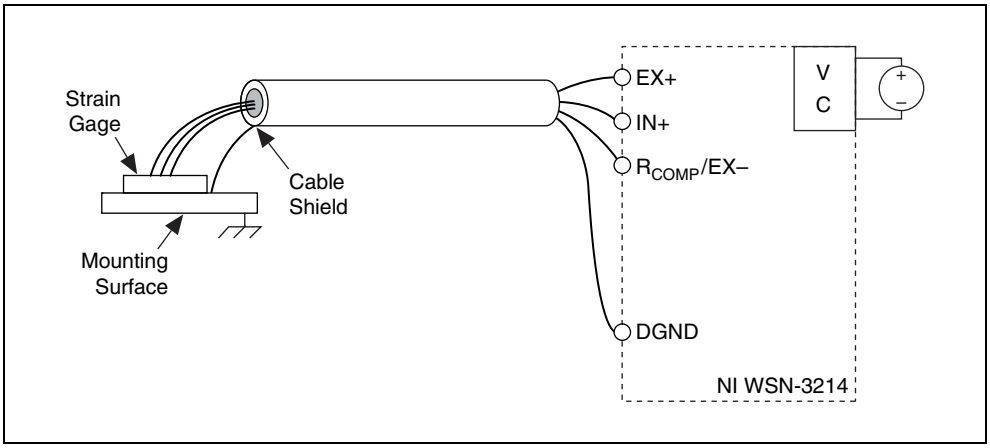


Figure 27. Quarter-Bridge Measurements Supplied From a Floating Power Supply

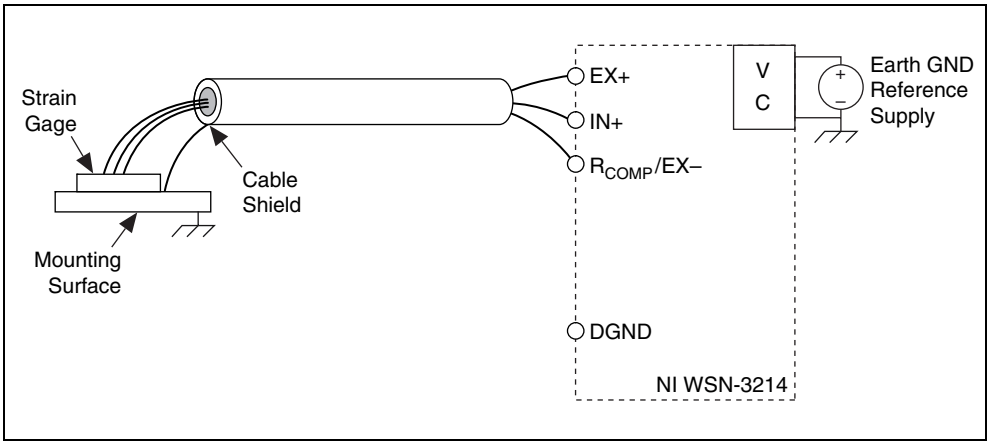


Figure 28. Quarter-Bridge Measurements Supplied From an Earth GND Referenced Supply.

Controlling Digital Inputs and Outputs

The following sections discuss how to configure the NI WSN-3214 device for different types of input and output, and how to connect external devices to the NI WSN-3214 DIO terminals.

On the 36-position screw terminal connector, terminals 16–18 and 34–36 are the DIO section. The DIO section has the following terminals:

- DIO*x*—signal terminal
- DGND—ground terminal
- DIO PWR—DIO Power positive (required when one of the DIO channels is configured for *Drive High (Sourcing)* or *Drive High and Low (Sinking and Sourcing)* mode)

Note Use the **Node Properties** dialog box in the LabVIEW Project Explorer window to change the DIO settings.

The NI WSN-3214 device has two bi-directional digital I/O channels. Each channel supports eight operational modes depending on whether the channel is configured as digital output or digital input. The NI-WSN software controls the different modes of operation by turning on and off the high side and low side switches.

Digital Output Operational Modes

The channels support the following digital output operational modes:

- *Drive High (Sourcing)*
- *Drive Low (Sinking)*
- *3V TTL Logic (Open-Collector with Pull-Up)*
- *Drive High and Low (Sinking and Sourcing)*

Note When configured in a digital output mode, reading the channel returns the state of the pin voltage with TTL thresholds.

Digital Input Operational Modes

The channels support the following digital input operational modes:

- *24 V Sinking*
- *24 V Sinking with Power Management*
- *TTL Logic*
- *Contact Closure*

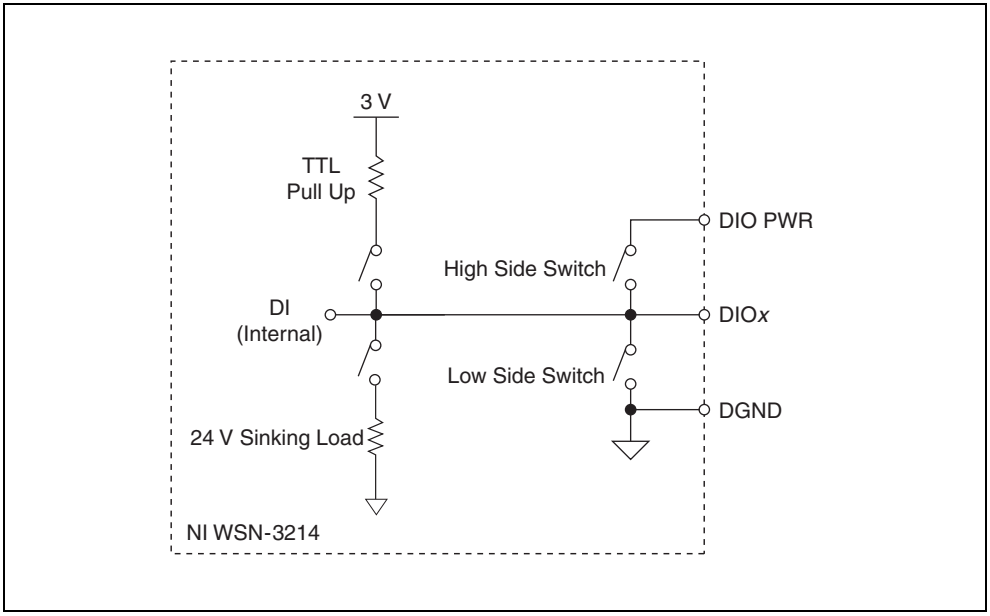


Figure 29. Simplified Circuit Diagram of One DIO Channel

Connecting Digital Outputs

You can connect a variety of industrial devices such as solenoids, relays, and indicators to the NI WSN-3214 device. Refer to the *Specifications* section to ensure compatibility.

Note You must use 2-wire ferrules to create a secure connection when connecting more than one wire to a single terminal on the NI WSN-3214.

Note You can connect only one external DIO PWR supply to the NI WSN-3214.

The power supply provides the current for the devices you connect to the NI WSN-3214. Connect the power supply positive lead to DIO PWR terminal and the power supply negative lead to one of the DGND terminals. The DIO PWR terminal on the NI WSN-3214 is internally connected to each digital channel. Refer to the *Specifications* section for information about the power supply voltage range.

Note The *Drive High (Sourcing)* and *Drive High and Low (Sinking and Sourcing)* modes require an external power supply connected to the DIO PWR terminal.

Drive High (Sourcing)

Drive High (Sourcing) mode is for devices that require high side drive or a sourcing output. When using this mode:

- Connect the device to DIO*x* and connect the device common to the DGND terminal corresponding to that DIO*x* terminal.
- The DIO*x* terminal is driven to the voltage supplied to DIO PWR when you turn on the channel.
- Writing a digital value of 1 turns on the channel, and 0 turns off the channel.
- The channel is high impedance when the channel is turned off (0).

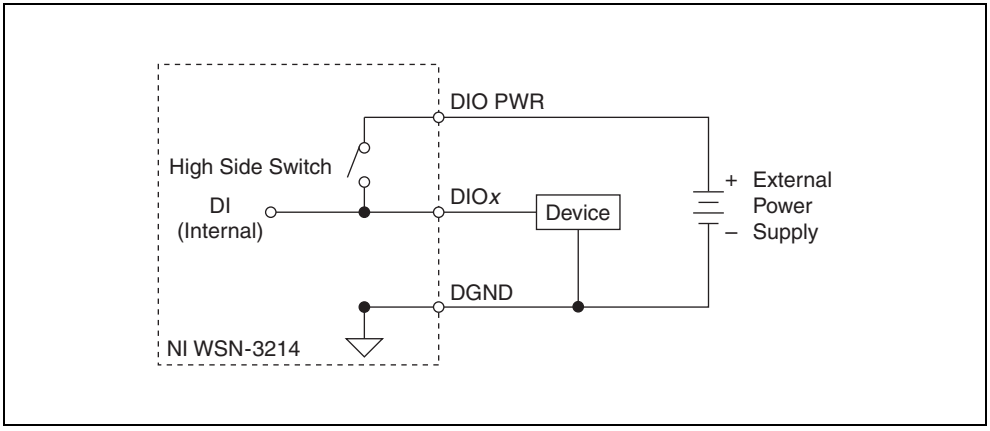


Figure 30. Connecting a Device to the NI WSN-3214 in Drive High Mode

Drive Low (Sinking)

Drive Low (Sinking) mode is for devices that require low side drive or a sinking output. When using this mode:

- The DIO*x* terminal is pulled to DGND when you turn on the channel.
- Writing a digital value of 0 turns on the channel, and writing a digital value of 1 turns off the channel.

- The channel is high impedance when the channel is turned off (1).
- When driving inductive loads, use an external flyback diode or snubber circuit, as shown in Figure 31.

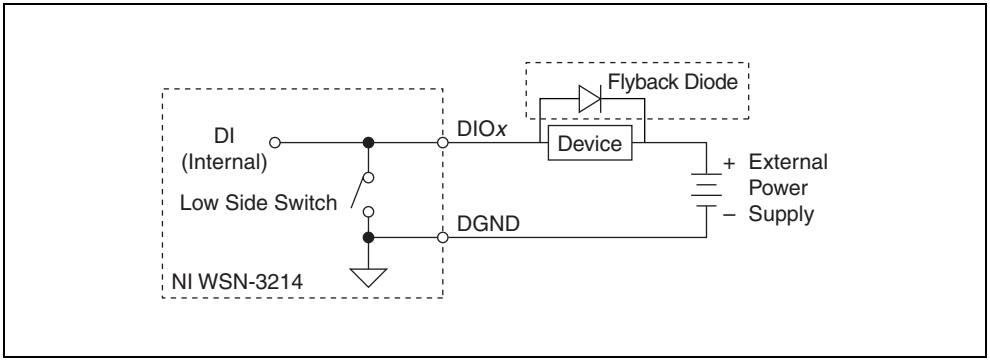


Figure 31. Connecting a Device to the NI WSN-3214 in Drive Low (Sinking) Mode

3V TTL Logic (Open-Collector with Pull-Up)

The 3V TTL Logic (Open-Collector with Pull-Up) mode can be used to connect to 3 V and 5 V logic inputs with TTL Logic compatible thresholds. When using this mode:

- The DIO*x* terminal is pulled-up to 3 V through a pull-up resistor for a DIO output value of 1 and driven low to ground for a DIO output value 0.
- The DIO line is read with 3V TTL Logic input thresholds.
- A supply voltage is not required on DIO PWR.

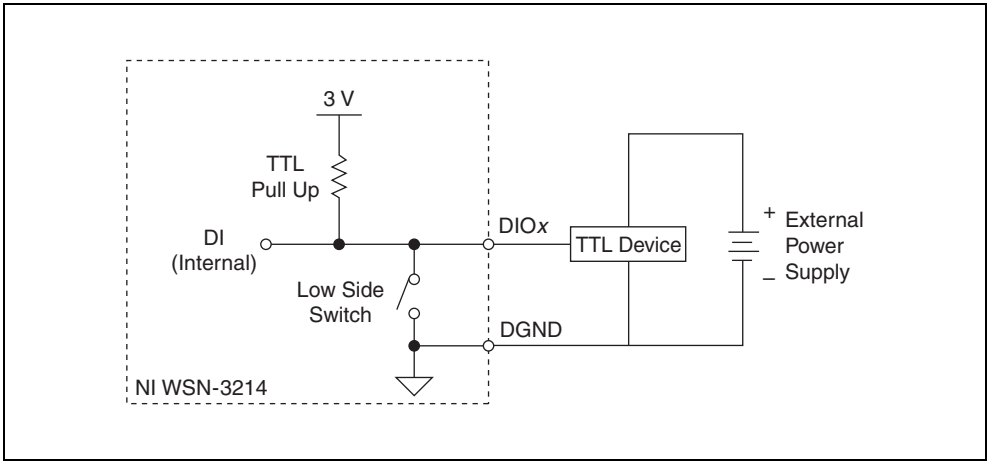


Figure 32. Connecting a Device to the NI WSN-3214 in 3V TTL Logic Mode

Drive High and Low (Sinking and Sourcing)

When using *Drive High and Low (Sinking and Sourcing)* mode:

- Connect the device to DIO*x* and connect the device common to the DGND terminal corresponding to that DIO*x* terminal.
- The DIO*x* terminal is driven to the voltage supplied to DIO PWR when you turn on the channel, and is driven to DGND when you turn off the channel.

- If a supply voltage is not connected to DIO PWR, it operates as if it is set to the *Drive Low (Sinking)* mode.
- Writing a digital value of 1 turns on the channel and writing a 0 turns the channel off.

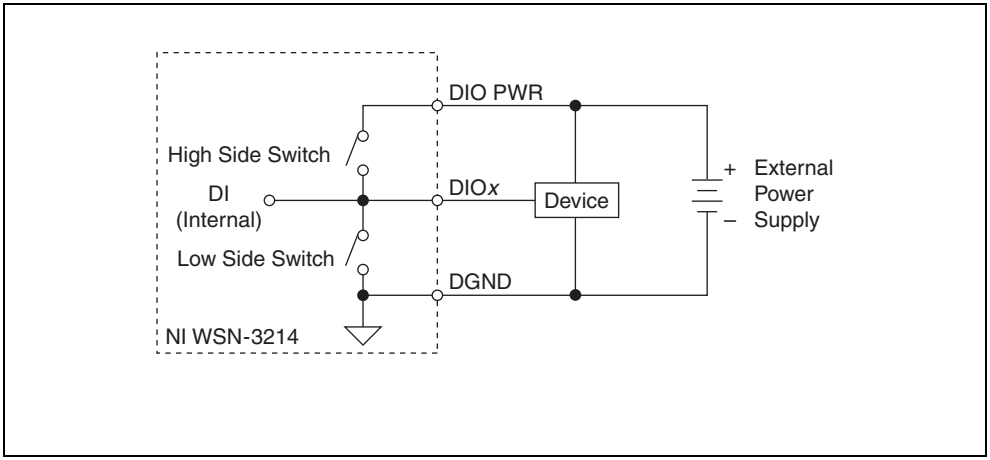


Figure 33. Connecting a Device to the NI WSN-3214 in Drive High and Low Mode

Connecting Digital Inputs

You can connect a variety of sensors, switches, and industrial devices to the NI WSN-3214 device. Refer to the *Specifications* section to ensure compatibility.

24 V Sinking

In 24 V Sinking mode, the DIO*x* terminal has a low impedance to ground and input thresholds compatible with 24 V signaling. Select this mode for connection to industrial 24 V/IEC1131 sourcing output devices.

24 V Sinking with Power Management

In 24 V Sinking with Power Management mode, the DIO*x* terminal is similar to 24 V Sinking mode, but the low impedance path to ground is removed when the inputs are not being actively read. This can reduce the power consumption of the output device. This mode should only be used with output devices that have valid output states within 100 µs of having a low impedance path presented to the output.

TTL Logic

TTL Logic mode is suitable for most 3 V or 5 V logic signals. The DIO*x* terminal has high impedance inputs with TTL Logic compatible thresholds.

Contact Closure

Contact Closure mode is suitable for connections to contact switches wired between the input and ground. The DIO*x* terminal has *TTL Logic* compatible thresholds and provides a pull-up resistor to 3 V when the input is being read. If a contact to ground remains closed while the DIO Notification property is enabled, the current into the contact switch increases power consumption and can reduce battery life.

Digital I/O Protection

The high side switch on each I/O channel has short circuit protection. The low side switch on each I/O channel is oversized to be able to withstand higher currents than when in normal operating conditions.

Understanding Short Circuit Protection

The current that flows through the high side switch is continuously sensed. If a current above the trip limit is detected, the current protection trips and turns off the high side switch. The protection latches in the tripped state and only resets when the high side switch is given the command to turn off. High inrush currents that exist for a short time do not trip the short-circuit protection. Refer to the *Specifications* section for more information about the maximum continuous output current, short circuit behavior, and short circuit trip time.

Preventing an Overcurrent Condition

Follow these recommendations to prevent an overcurrent condition:

- Do not connect DIO PWR to ground.
- Do not ground unused terminals.
- Do not exceed the output current rating of the channel.
- Do not exceed the voltage ratings of the channel.

Detecting an Overcurrent Condition

To check whether or not the short circuit protection is tripped, the logic state of the DIO pin can be read when driving high using the digital input function. If DO is set to *Drive High (Sourcing)* or *Drive High and Low (Sinking and Sourcing)* modes and a digital value of 1 is written to the channel, a logical 1 should be read from the channel. If a logical 0 is read instead, then the current protection is tripped or a fault is preventing the high side switch from driving the output high.

Resetting Channels After an Overcurrent Condition

To reset the short circuit protection turn off the high side switch by writing a digital value of 0 to the channel. Then, check the wiring and remove any possible faults. The correct functionality of the circuit should be confirmed by writing a digital value 1 to the channel and then reading a logical 1 from it.

Battery Considerations

NI WSN-3214 power consumption is different depending on whether or not you are using NI-WSN or NI LabVIEW WSN.

NI-WSN

If you are using NI-WSN, you have control of the data using the following settings: waveform interval, sample rate, number of samples per waveform, acquisition mode or bridge type. At each waveform interval the NI WSN-3214 transmits the acquired data to the gateway. The size of the acquired data varies along with the number of channels being measured and with the number of samples per waveform. For each channel that is being measured a certain radio communication protocol is repeated, meaning that the power required by the radio is directly proportional to the number of channels that are being measured. As more samples per waveform are acquired, these are split into packages when sent, which increases the amount of power required to send them.

The following timing diagram shows how the NI WSN-3214 acquires and sends data using NI-WSN.

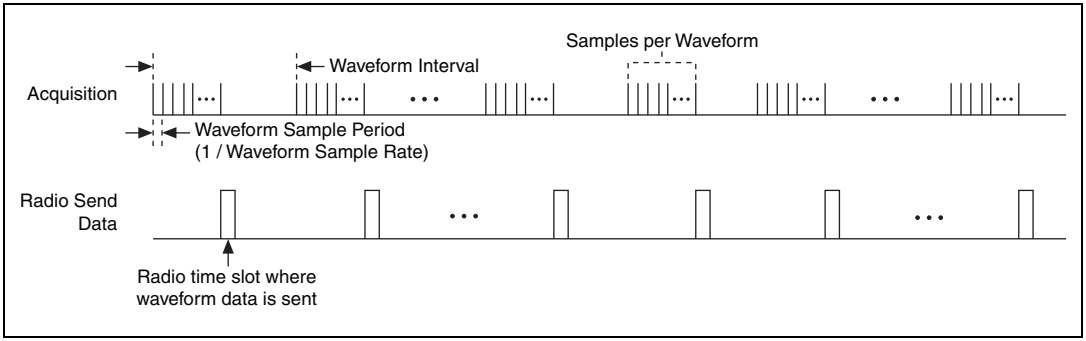
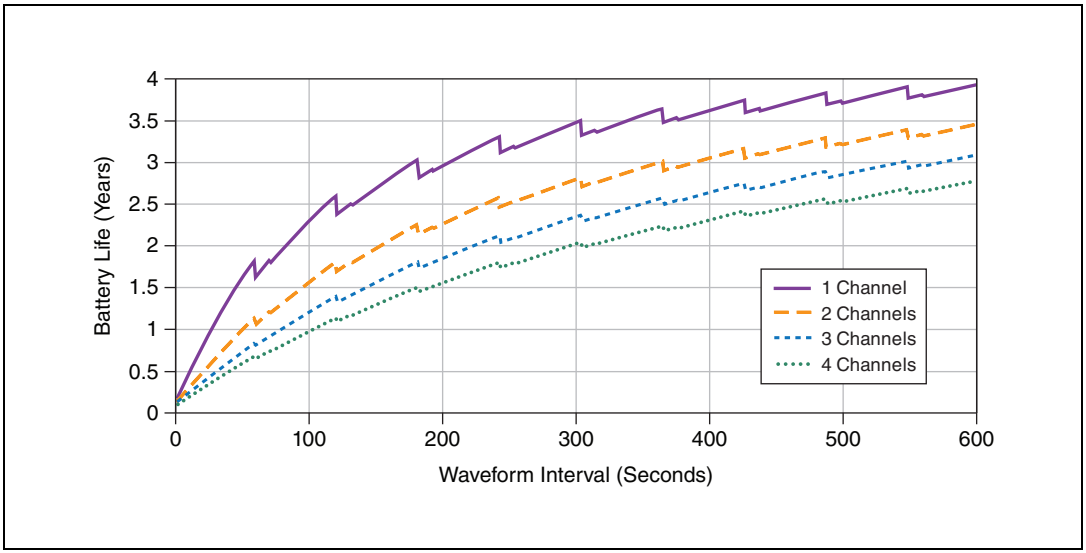


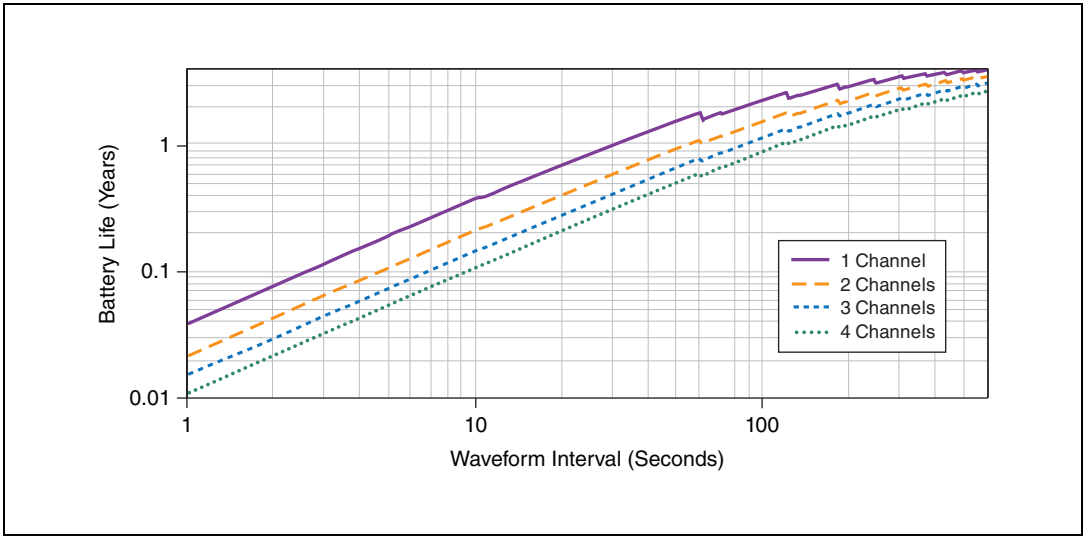
Figure 34. NI-WSN Waveform Acquisition Timing

The following graphs demonstrate estimated battery life under common conditions.



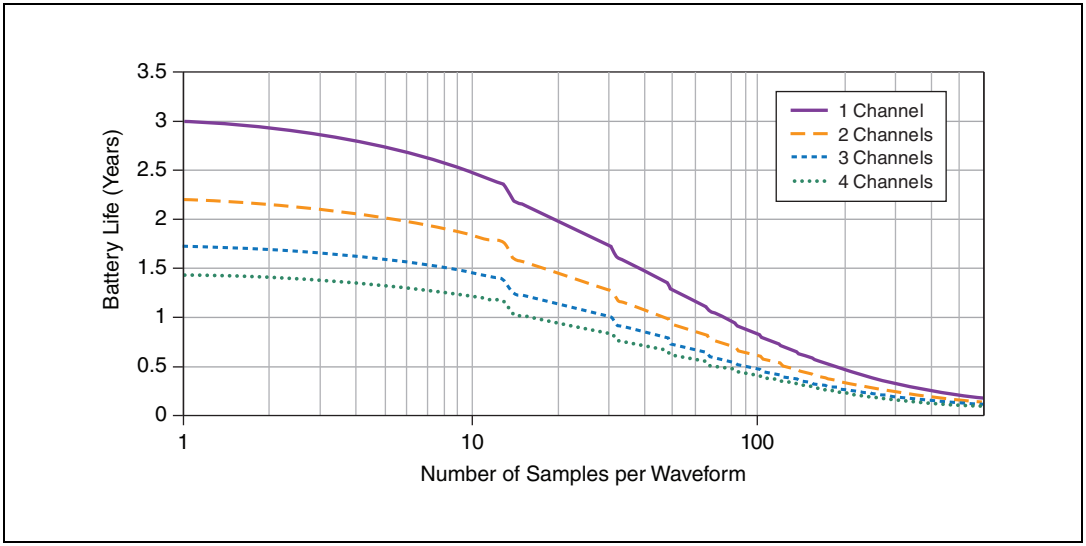
Test Conditions: NI-WSN, 1 Sample per Waveform, 50/60 Hz High Rejection, 350 Ω Full-Bridge

Figure 35. NI-WSN Battery Life Versus Waveform Interval and Number of Channels



Test Conditions: NI-WSN, 1 Sample per Waveform, 50/60 Hz High Rejection, 350 Ω Full-Bridge

Figure 36. NI-WSN Battery Life Versus Waveform Interval and Number of Channels



Test Conditions: NI-WSN, 180 Seconds Waveform Interval, 50/60 Hz High Rejection, 350 Ω Full-Bridge

Figure 37. NI-WSN Battery Life Versus Number of Samples per Waveform

NI LabVIEW WSN

If you are using NI LabVIEW WSN, the expected battery life of your NI WSN-3214 can vary greatly based on your NI LabVIEW WSN program, waveform interval, waveform sample rate, number of samples per waveform, acquisition mode or bridge type. Given a small number of samples per waveform the largest contributor to the power consumption is the radio communication. NI LabVIEW WSN allows you to select the amount of data that you send over the radio, and when to send it, increasing the expected

battery life. You can select to send Waveforms or User-Defined I/O Variables (UDV). One example of an application where you can extent the battery life of your NI WSN-3214 is when you take measurements, but you choose to send only the average or the minimum and maximum of the acquired data as UDVs.

The following timing diagram shows how the NI WSN-3214 acquires and sends data using NI LabVIEW WSN.

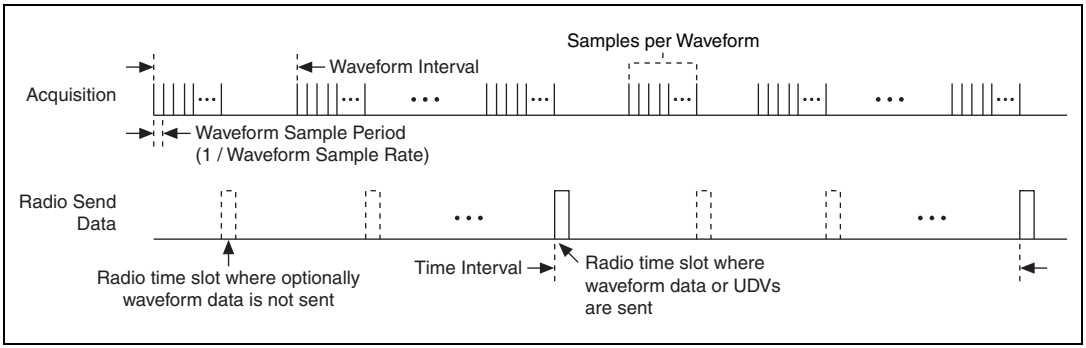
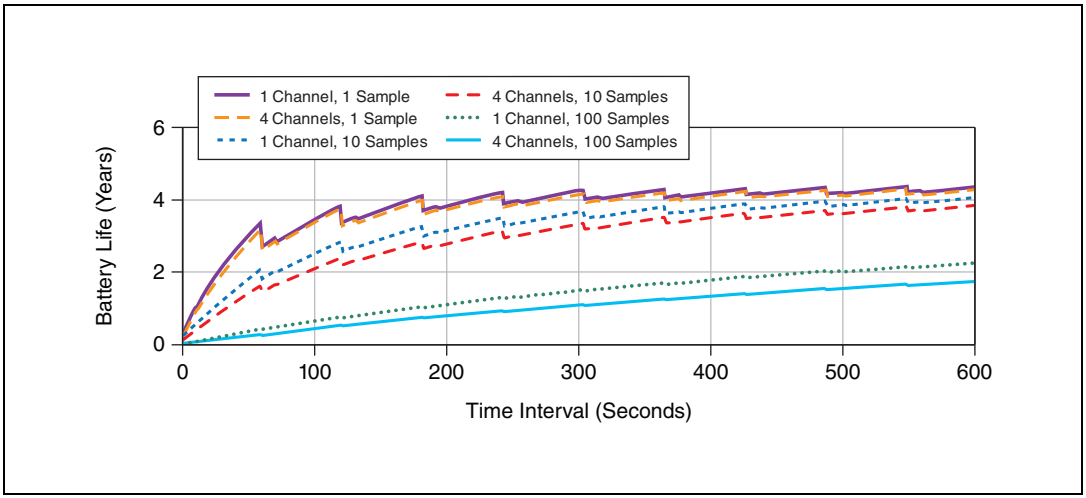


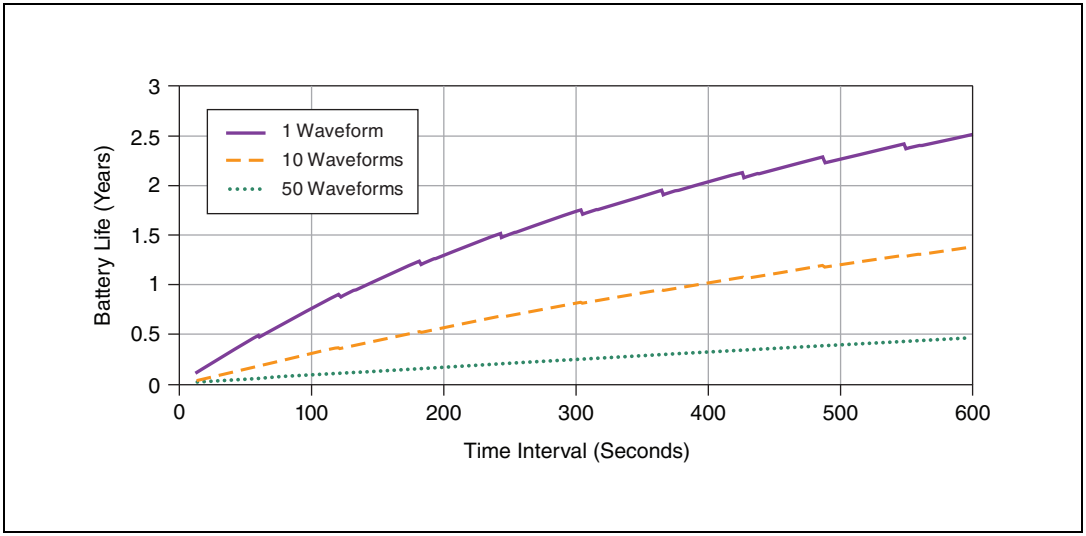
Figure 38. NI LabVIEW WSN Waveform Acquisition Timing

The following graphs demonstrate estimated battery life under common conditions.



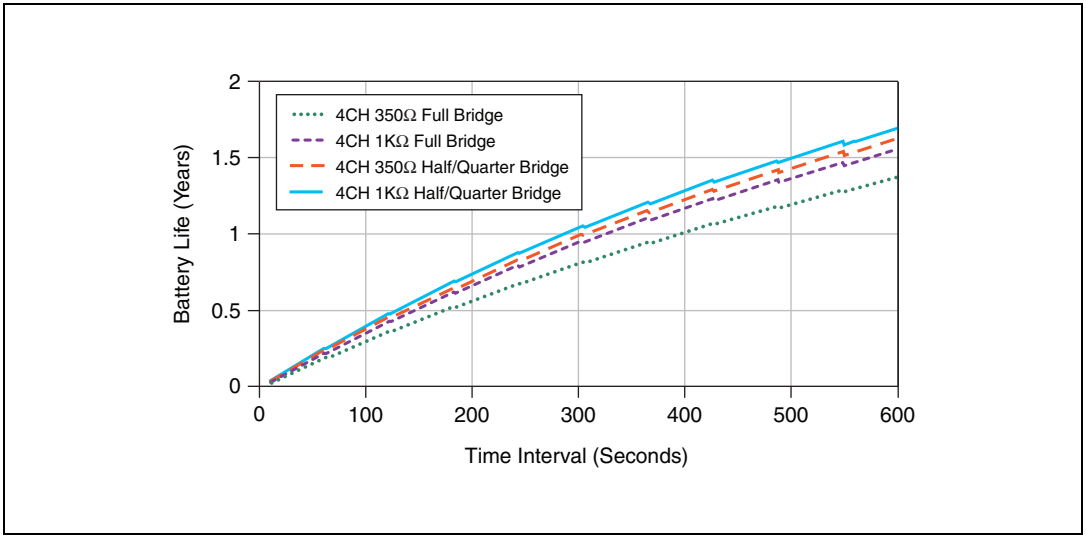
Test Conditions: NI LabVIEW WSN Module, up to 10 User-defined Variables Sent per Radio Interval, 50/60 Hz High Rejection

Figure 39. NI LabVIEW WSN Battery Life Versus Time Intervals, Number of Channels, and Number of Samples per Waveform with No Waveform Sent Over the Radio



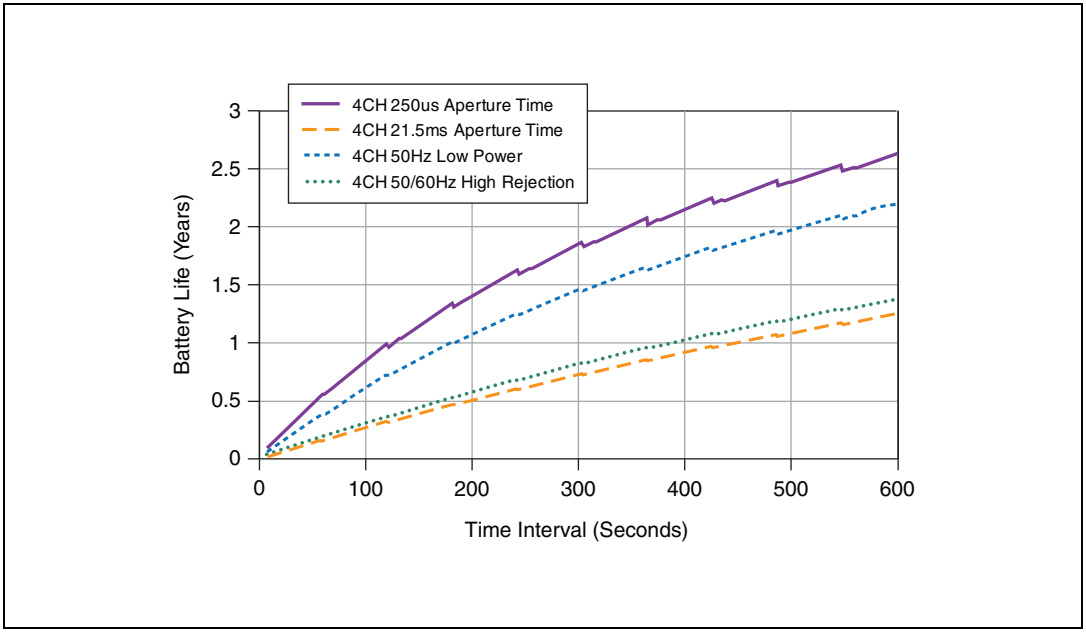
Test Conditions: NI LabVIEW WSN Module, 10 Samples per Waveform, 50/60 Hz High Rejection, 4 Channels, 350 Ω Full-Bridge

Figure 40. NI LabVIEW WSN Battery Life Versus Time Interval and Number of Waveforms Acquired for Each Waveform Sent Over Radio



Test Conditions: NI LabVIEW WSN Module, 10 Samples per Waveform, 50/60 Hz High Rejection, 4 Channels

Figure 41. NI LabVIEW WSN Battery Life Versus Time Interval and Bridge Type



Test Conditions: NI LabVIEW WSN Module, 10 Samples per Waveform, 4 Channels, 350 Ω Full-Bridge, 10 Waveforms Acquired, 1 Waveform Sent Over Radio for a Sampling Interval

Figure 42. NI LabVIEW WSN Battery Life Versus Time Interval and Acquisition Mode for Multiple Waveform Acquisitions

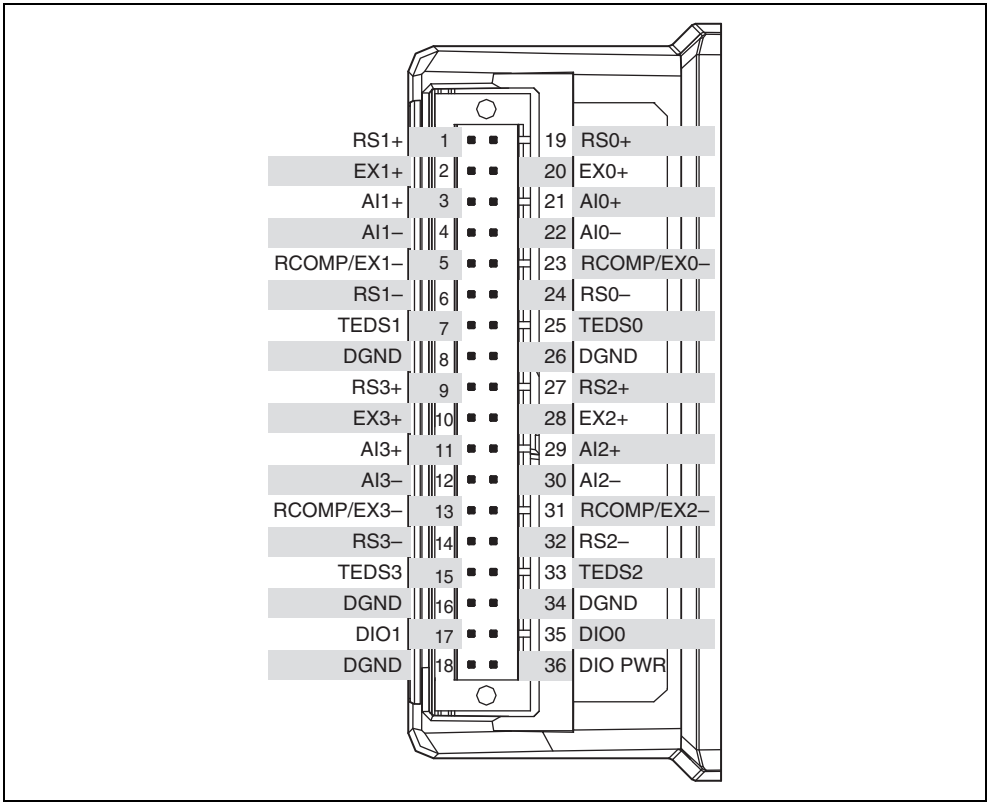


Figure 43. NI WSN-3214 Pinout

TEDS Channels

The TEDS channels on the NI WSN-3214 are reserved for future use by National Instruments.

Specifications

These specifications are typical from –40 to 70 °C, and assume high rejection strength mode and 50/60 Hz filter rejection mode unless otherwise noted. Some specifications (such as sample interval and power consumption) can be optimized by customizing node behavior with the NI LabVIEW Wireless Sensor Network (WSN) Module Pioneer. Refer to the *LabVIEW WSN Performance Benchmarks* documents, at `zone.ni.com`, for more information.

For the NI WSN gateway specifications, refer to the gateway documentation.

Caution Electromagnetic interference can adversely affect the measurement accuracy of this product. The analog input terminals of this device are not protected for electromagnetic interference. As a result, this device may experience reduced measurement accuracy or other temporary performance degradation when connected cables are routed in an environment with radiated or conducted radio frequency electromagnetic interference. To limit radiated emissions and to ensure that this device functions within specifications in its operational electromagnetic environment, take precautions when designing, selecting, and installing measurement probes and cables.

Analog Input Characteristics

Number of channels ..... 4 analog input channels

Sampling mode ..... Scanned

ADC resolution ..... 20 bits

Type of ADC ..... Oversampled converter

DNL ..... No missing codes guaranteed

Modes (configurable per channel) ..... Full-bridge, half-bridge, quarter-bridge

Bridge completion

- Quarter-bridge and half-bridge ..... Internal

Bridge resistance

- Full-bridge ..... 350–1,000 Ω
- Half-bridge ..... 350–1,000 Ω
- Quarter-bridge ..... 350, 1,000 Ω

Powerline filtering modes ..... 50 Hz, 60 Hz, 50/60 Hz, none

Overvoltage protection ..... ±30 VDC

Input range ..... ±20 mV/V

Table 3. Accuracy

Measurement Conditions*	Percent of Reading (Gain Error)	Percent of Range†+ (Offset Error)		
		Full-Bridge	Half-Bridge	Quarter-Bridge
Typical, 25 °C, ±5 °C	±0.1%	±0.005% (1 µV/V)	±0.7% (140 µV/V)	±0.5% (100 µV/V)
Maximum, –40 to 70 °C	±0.45%	±0.03 (6 µV/V)	±1% (200 µV/V)	±1% (200 µV/V)

* After using shunt calibration for quarter-bridge and using remote sensing for full/half-bridge to remove errors from lead wire resistance

† Range equals 20 mV/V.

+Before offset null. The offset error can be removed for current temperature conditions by using offset null. After doing offset null, the offset error of the measurement is determined by the temperature drifts over the expected temperature range. For example, if you perform an offset null for a half-bridge measurement at a temperature of 25 °C and the expected temperature variation is 20 °C, then the typical offset error for the measurement is as follows:

$$\text{offset error}_{HB} = 0.6\frac{uV}{V} \times \frac{1}{°C} \times 20°C = 12\frac{uV}{V} \text{ (0.06\% of range)}$$

Gain drift.....±10 ppm/°C

Offset drift

Full-bridge .....±0.05 µV/V per °C

Half-bridge.....±0.6 µV/V per °C

Quarter-bridge.....±1 µV/V per °C

Shunt calibration

Selection.....Software selectable

Resistance .....50 KΩ

350 Ω accuracy

25°C .....±0.12%

–40 to 70 °C.....±0.22% maximum

1KΩ accuracy

25 °C .....±0.11%

–40 to 70 °C.....±0.19% maximum

Table 4. Maximum Sampling Rate and Input Noise

Measurement Conditions	1 Channel Sampling Rate (SPS*)	2 Channel Sampling Rate (SPS)	3 Channel Sampling Rate (SPS)	4 Channel Sampling Rate (SPS)	Total Noise ($\mu V/V_{rms}$)
Aperture time 250 µs	4,096	1,560	1,092	862	0.76
Aperture time 400 µs	2,340	992	697	537	0.54
Aperture time 750 µs	1,260	585	404	306	0.38
Aperture time 1.4 ms	668	168	217	164	0.27
Aperture time 2.8 ms	344	86	113	85	0.19
Aperture time 5.5 ms	175	43	57	43	0.14
Aperture time 10.8 ms	88	44	29	22	0.1
Aperture time 21.5 ms	44	22	14	11	0.07
Filter: 50 Hz Low Power	49	49	49	49	0.09
Filter: 60 Hz Low Power	59	59	59	59	0.1
Filter: 50 Hz High Rejection	25	25	25	25	0.08

Table 4. Maximum Sampling Rate and Input Noise (Continued)

Measurement Conditions	1 Channel Sampling Rate (SPS*)	2 Channel Sampling Rate (SPS)	3 Channel Sampling Rate (SPS)	4 Channel Sampling Rate (SPS)	Total Noise ($\mu V/V_{rms}$)
Filter: 60 Hz High Rejection	30	30	30	30	0.08
Filter: 50/60 Hz Low Power	27	27	27	27	0.08
Filter: 50 Hz/60 Hz High Rejection	13	13	13	13	0.07

* Samples per second.

Table 5. Normal Mode Rejection, Filter Characteristics

Filter Strength	Filter Rejection
High rejection	–60 dB at 50 and/or 60 Hz, ±1 Hz
Low power	–30 dB at 50 and/or 60 Hz, ±1 Hz

Excitation

Excitation type ..... Voltage

Voltage ..... 2 V, ±0.85% maximum

Maximum current ..... 6.4 mA

Maximum allowable lead resistance per lead wire

350 Ω full-bridge ..... 17 Ω

1 KΩ full-bridge ..... 50 Ω

350 Ω half-bridge and quarter-bridge ..... 33 Ω

1 KΩ half-bridge and quarter-bridge ..... 90 Ω

Digital I/O

Number of channels 2

Power-on output state ..... High impedance

DIO pin capacitance ..... 2,000 pF

Digital Input

Modes (configurable per channel) ..... *24 V Sinking*, *24 V Sinking with Power Management*, *TTL Logic*, *Contact Closure*

Input voltage range ..... 3.3 to 24 VDC maximum

Digital input logic level thresholds

TTL Logic and Contact Closure modes

High level (ON) input voltage .....≥2 V

Low level (OFF) input voltage.....≤0.8 V

24 V modes

IEC 61131-2 compatibility .....Type 1 and 3

High level (ON) input voltage .....≥10 V

High level (ON) input current.....≥2 mA

High level (OFF) input voltage.....≤6 V

Low level (OFF) input current.....≤1 mA

Input current

TTL Logic and Contact Closure modes.....≤375 µA at 30 V
≤110 µA at 5 V
≤80 µA at 3 V

Contact Closure mode pull-up current.....≤175 µA through closed contact

24 V modes .....≤6.4 mA at 30 V
≤3.2 mA at 15 V

Minimum detectable pulse width

TTL Logic mode.....30 µs

24 V modes .....30 µs

Contact Closure mode.....100 µs

Digital Output

Modes (configurable per channel) .....*Drive High (Sourcing)*, *Drive Low (Sinking)*, *Drive High and Low (Sinking and Sourcing)*, and *3V TTL Logic (Open-Collector with Pull-Up)*

DIO power supply voltage range (V_{DIO_PWR}) .....3.3 to 24 V

Sourcing current (one channel).....0.25 A maximum

Sinking current (per channel) .....1 A maximum

Output voltage

Sourcing .....>(V_{DIO_PWR}–750 mV) with I_{OUT} <0.25 A

Sinking .....<50 mV with I_{OUT} <1 A

3V TTL Logic mode pull-up .....>2 V with I_{OUT} <20 µA

DO protection

Voltage .....+30 VDC maximum

Reversed voltage.....None

Short circuit (sourcing)

Trip current .....0.26 A minimum, 1.2 A maximum

Trip time.....<250 µs, at 1.2 A

Overcurrent (sinking).....6.5 A maximum

DO propagation delay

Sinking ..... 250 µs

Sourcing ..... 2.5 ms

Node Resources for LabVIEW WSN Module

Minimum sample interval ..... 0.5 s

User flash size ..... 188 KB

User RAM size ..... 2 MB

Number of flash erase cycles per sector 100,000

Wireless Characteristics

Radio mode ..... IEEE 802.15.4

RF data rate ..... 250 Kbps

Range

Americas ..... Up to 300 m

International ..... Up to 150 m

Frequency band[1] ..... ISM 2.4 GHz (2400 MHz to 2483.5 MHz)

Channels[1] 11–24

TX power

Americas ..... +17 dBm maximum (50 mW)

International ..... +10 dBm maximum

Modulation type ..... DSSS (O-QPSK)

Receiver sensitivity ..... –102 dBm

Antenna

Connector ..... Female RP-SMA connector

VSWR ..... 2.0 maximum

Impedance ..... 50 Ω

Directivity ..... Omni

Nominal gain ..... 1.5 dBi

Power Requirements

The following power requirements specifications are typical at 25 °C.

Battery Power

Caution Do not use rechargeable batteries.

Internal battery ..... 4 AA 1.5 V alkaline or lithium batteries

Only use the following batteries ..... Energizer E91 AA, alkaline
Duracell MN1500 AA, alkaline
Energizer L91 AA, lithium

[1] Due to regulations, the frequency bands depend upon country of operation.

Battery operating temperature range

Energizer E91.....–18 °C to 55 °C

Duracell MN1500 .....–20 °C to 54 °C

Energizer L91.....–40 °C to 60 °C

Voltage range .....3.6 to 7.5 V

Power consumption[1]

Sleep mode.....0.3 mW

Note Power consumption and battery life varies per application. Refer to the *Battery Considerations* section for examples that show how battery performance is impacted by settings like samples per waveform and sample interval.

External Power

Caution You *must* use a UL Listed ITE power supply marked LPS with the NI WSN-3214. The power supply must also meet any safety and compliance requirements for the country of use.

Voltage range .....5 to 30 V

Power input mating connector .....2-position mini-combicon,
Phoenix Contact part number: 1714977

Power consumption[2]

Sleep mode.....1 mW

60 second sample interval.....4 mW at 12 V

5 second sample interval.....40 mW at 12 V

Router mode[3] .....200 mW at 12 V

Physical Characteristics

Screw-terminal wiring .....14 to 24 AWG wire

Torque for screw terminals .....0.2 to 0.25 N · m

Dimensions .....Refer to Figure 2 for device dimensions

Weight.....Approx. 242 g (8.5 oz)

Weight with antenna .....Approx. 256 g (9 oz)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI WSN-3214 at `ni.com/calibration`.

Calibration interval .....3 years

Safety Standards

Caution Do not operate the NI WSN-3214 in a manner not specified in this user guide. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to National Instruments for repair.

[1] Device executing NI-WSN firmware.

[2] Device executing NI-WSN firmware. 4 channels, 10 S/waveform, 50/60 Hz high rejection.

[3] Router connected directly to a NI WSN gateway. 1 second sample interval.

The NI WSN-3214 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label, or go to `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Hazardous Locations

U.S. (UL) .....Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nC IIC T4

Canada (C-UL) .....Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nL IIC T4

Europe (DEMKO).....Ex nA nL IIC T4

Safety Voltages

Connect only voltages that are within these limits.

V terminal to C terminal .....30 V maximum, Measurement Category I

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the system to signals or use for measurements within Measurement Categories II, III, or IV.

RF Safety Warning

This equipment complies with FCC radiation exposure limits set for uncontrolled equipment and meets the FCC radio frequency (RF) Exposure Guidelines in Supplement C to OET65. This product generates and radiates radio frequency energy. To comply with the radio frequency radiation exposure guidelines in an uncontrolled environment, this equipment should be installed and operated with at least 20 cm between the radiator and the person's body (excluding extremities: hands, wrists, feet, and legs).

This equipment complies with the European Council Recommendation (1995/519/EC) on the limitation of exposure of the general public to electromagnetic fields. Compliance was determined in accordance with the requirements in EN 50371.

Environmental

Operating temperature
(IEC-60068-2-1 and IEC-60068-2-2) .....– 40 to 70 °C

Storage temperature
(IEC-60068-2-1 and IEC-60068-2-2) .....– 40 to 85 °C

Operating humidity (IEC-60068-2-56).....10 to 90% RH, noncondensing

Storage humidity (IEC-60068-2-56).....5 to 95% RH, noncondensing

Pollution Degree (IEC 60664) 2

Maximum altitude.....2,000 m

Indoor use only

Shock and Vibration

Operating vibration, random (IEC 60068-2-64) ....5 g_{rms}, 10 to 500 Hz

Operating shock (IEC 60068-2-27) .....30 g, 11 ms half sine,
50 g, 3 ms half sine,
18 shocks at 6 orientations

Operating vibration,
sinusoidal (IEC 60068-2-6) .....5 g, 10 to 500 Hz

Electromagnetic Compatibility

This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326-2 (IEC 61326-2): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

The NI WSN-3214 also meets the requirements of the following EMC standards for intentional radiators:

- EN 300 328
- EN 301 489-1 and EN 301 489-17
- FCC 47 CFR Part 15C
- IC RSS-210

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generates radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC certification and additional information, refer to the product label or the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility (EMC) Directive
- 1999/5/EC; Radio and Telecommunications Terminal Equipment (R&TTE) Directive

United States

This product generates and radiates radio frequency energy. To comply with the radio frequency radiation exposure guidelines in an uncontrolled environment, this equipment must be installed and operated while maintaining a minimum body-to-antenna distance of 20 cm.

This product complies with Part 15 of the FCC Rules. Operation is subject to these two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This product does not contain any user serviceable components. Any unauthorized product changes or modifications will invalidate the warranty and all applicable regulatory certifications and approvals.

Canada

This product complies with Industry Canada RSS-210.

Cet appareil est conforme aux norme RSS210 d'Industrie Canada.

Europe—EU Declaration of Conformity CE

Marking by the above CE symbol on the label indicates compliance with the Essential Requirements of the R&TTE Directive of the European Union (1999/5/EC). This equipment meets the following conformance standards: EN 300 893, EN 300 328, EN 301 489-17, EN 60950.

Europe – Restrictions for Use of 2.4 GHz Frequencies in European Community Countries

België/ Belgique:	For private usage outside buildings across public grounds over less than 300m no special registration with IBPT/BIPT is required. Registration to IBPT/BIPT is required for private usage outside buildings across public grounds over more than 300m. For registration and license please contact IBPT/BIPT.
	Voor privé-gebruik buiten gebouw over publieke groud over afstand kleiner dan 300m geen registratie bij BIPT/IBPT nodig; voor gebruik over afstand groter dan 300m is wel registratie bij BIPT/IBPT nodig. Voor registratie of licentie kunt u contact opnemen met BIPT.
	Dans le cas d'une utilisation privée, à l'extérieur d'un bâtiment, au-dessus d'un espace public, aucun enregistrement n'est nécessaire pour une distance de moins de 300m. Pour une distance supérieure à 300m un enregistrement auprès de I'IBPT est requise. Pour les enregistrements et licences, veuillez contacter l'IBPT.
Deutschland:	License required for outdoor installations. Check with reseller for procedure to follow.
	Anmeldung im Outdoor-Bereich notwendig, aber nicht genehmigungspflichtig.Bitte mit Händler die Vorgehensweise abstimmen.
France:	Restricted frequency band: only channels 1 to 7 (2400 MHz and 2454 MHz respectively) may be used outdoors in France. Check with the Telecommunications and Postal Regulation Authority (http://www.arcep.fr) for procedure to follow.
	Bande de fréquence restreinte : seuls les canaux 1–7 (2400 et 2454 MHz respectivement) doivent être utilisés endroits extérieur en France. Vous pouvez contacter l'Autorité de Régulation des Communications Electroniques et des Postes (http://www.arcep.fr) pour la procédure à suivre.
Italia:	General authorization required for outdoor use. Check with reseller for procedure to follow.
	E'necessaria un'autorizzazione generale per l'uso esterno. Verificare con i rivenditori la procedura da seguire.

Nederland:	License required for outdoor installations. Check with reseller for procedure to follow.
	Licentie verplicht voor gebruik met buitenantennes. Neem contact op met verkoper voor juiste procedure.

Japan

The certified radio equipment is embedded in this device.

本機器には認証済み無線設備が内蔵されています

Singapore

Complies with IDA Standards DA105692

Taiwan R.O.C.

低功率電波輻射性電機管理辦法
第十二條經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。
第十四條低功率射頻電機之使用不得影響飛航安全及幹擾合法通信；經發現有幹擾現象時，應立即停用，並改善至無幹擾時方得繼續使用。
前項合法通信，指依電信規定作業之無線電信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之幹擾。

EU Regulatory Statements

cs Česky [Czech]	*National Instruments* tímto prohlašuje, _e tento NI WSN-3214 je ve shodě se základními po_adavky a dalšími příslušnými ustanoveními směrnice 1999/5/ES.
da Dansk [Danish]	Undertegnede *National Instruments* erklćrer herved, at fřlgende udstyr NI WSN-3214 overholder de vćsentlige krav og řvrige relevante krav i direktiv 1999/5/EF.
de Deutsch [German]	Hiermit erklärt *National Instruments*, dass sich das Gerät NI WSN-3214 in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 1999/5/EG befindet.
et Eesti [Estonian]	Käesolevaga kinnitab*National Instruments* seadme NI WSN-3214 vastavust direktiivi 1999/5/EÜ põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele.
en English	Hereby, *National Instruments*, declares that this NI WSN-3214 is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
es Español [Spanish]	Por medio de la presente *National Instruments* declara que el NI WSN-3214 cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 1999/5/CE.

el Ελληνική [Greek]	ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ *National Instruments* ΔΗΛΩΝΕΙ ΟΤΙ NI WSN-3214 ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 1999/5/ΕΚ.
fr Français [French]	Par la présente *National Instruments* déclare que l'appareil NI WSN-3214 est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 1999/5/CE.
it Italiano [Italian]	Con la presente *National Instruments* dichiara che questo NI WSN-3214 è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/CE.
lv Latviski [Latvian]	Ar šo *National Instruments* deklarē, ka NI WSN-3214 atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiem ar to saistītajiem noteikumiem.
lt Lietuvių [Lithuanian]	Šiuo *National Instruments* deklaruoja, kad šis NI WSN-3214 atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas.
nl Nederlands [Dutch]	Hierbij verklaart *National Instruments* dat het toestel NI WSN-3214 in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EG.
mt Malti [Maltese]	Hawnhekk, *National Instruments*, jiddikjara li dan NI WSN-3214 jikkonforma mal-htigijiet essenzjali u ma provvedimenti ohrajn relevanti li hemm fid-Dirrettiva 1999/5/EC.
hu Magyar [Hungarian]	Alulírott, *National Instruments* nyilatkozom, hogy a NI WSN-3214 megfelel a vonatkozó alapvetõ követelményeknek és az 1999/5/EC irányelv egyéb elõírásainak.
pl Polski [Polish]	Niniejszym *National Instruments*. oświadcza, że NI WSN-3214 jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC.
pt Português [Portuguese]	*National Instruments* declara que este NI WSN-3214 está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE.
sl Slovensko [Slovenian]	*National Instruments* izjavlja, da je ta NI WSN-3214 v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES.
sk Slovensky [Slovak]	*National Instruments* týmto vyhlasuje, _e NI WSN-3214 spĺňa základné po_iadavky a všetky príslušné ustanovenia Smernice 1999/5/ES.
fi Suomi [Finnish]	*National Instruments* vakuuttaa täten että NI WSN-3214 tyyppinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.
sv Svenska [Swedish]	Härmed intygar *National Instruments* att denna NI WSN-3214 står I överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EG.
Íslenska [Icelandic]	Hér með lýsir *National Instruments* yfir því að NI WSN-3214 er í samræmi við grunnkröfur og aðrar kröfur, sem gerðar eru í tilskipun 1999/5/EC.
no Norsk [Norwegian]	*National Instruments* erklærer herved at utstyret NI WSN-3214 er i samsvar med de grunnleggende krav og øvrige relevante krav i direktiv 1999/5/EF.

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at `ni.com/environment`. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit `ni.com/environment/weee`.

Battery Replacement and Disposal

Battery Directive After replacement, recycle the old battery. For information about the available collection and recycling scheme (and your nearest National Instruments Branch Office) or on Battery Directive compliance (Directive 2006/66/EC of the European Parliament and Council) in a particular EU country visit `ni.com/company/citizenship/product.htm#battery`.

Taiwan R.O.C.

电子信息产品污染控制管理办法 （中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at ni.com/support and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of ni.com/niglobal to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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